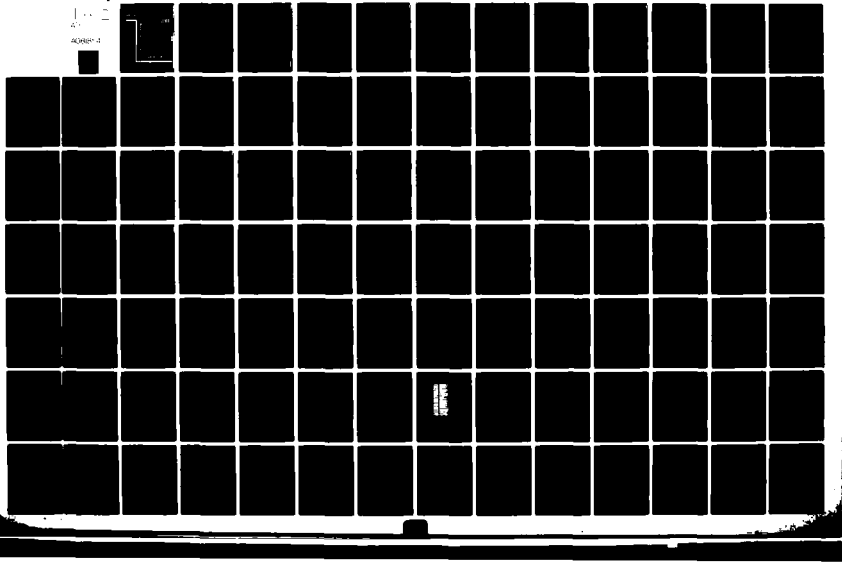
AD-A081 854 MCDONNELL DOUGLAS ASTRONAUTICS CO ST LOUIS MO F/G 5/9
INTEGRATED SYSTEM TEST OF THE ADVANCED INSTRUCTIONAL SYSTEM (AI--ETC(U)
DEC 79 L M LINTZ, R PENNELL, J Y YASUTAKE F33615-73-C-4004
UNCLASSIFIED AFHRL-TR-79-40 NL



AFHRL-TR-79-40

# AIR FORCE HUMAN RESOURCES LABORATORY



## INTEGRATED SYSTEM TEST OF THE ADVANCED INSTRUCTIONAL SYSTEM (AIS)



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December 1979

Final Report



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This final report was submitted by McDonnell Douglas Astronautics Co. – St. Louis, P.O. Box 516, St. Louis, Missouri 63166, under contract F33615-73-C-4004, project 1193, with Technical Training Division, Air Force Human Resources Laboratory (AFSC), Lowry Air Force Base, Colorado 80230. Dr. Joseph Y. Yasutake was the Contract Monitor for the Laboratory.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

# REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFHRL-TR-79-40
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): INTEGRATED SYSTEM TEST OF THE ADVANCED INSTRUCTIONAL SYSTEM (AIS).
5. TYPE OF REPORT & PERIOD COVERED: Final report
6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): Larry M. Lintz, Roger Pennell, Joseph Y. Yasutake
8. CONTRACT OR GRANT NUMBER(s): F33615-73-C-4004

9. PERFORMING ORGANIZATION NAME AND ADDRESS: McDonnell Douglas Astronautics Co. – St. Louis, P.O. Box 516, St. Louis, Missouri 63166
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 63751F, 11930207

11. CONTROLLING OFFICE NAME AND ADDRESS: HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235
12. REPORT DATE: December 1979
13. NUMBER OF PAGES: 106

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado 80230
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Advanced Instructional System (AIS)
Computer-Assisted Instruction (CAI)
computer-based instruction
computer-based training
Computer-Managed Instruction (CMI)
instructional systems evaluation
instructional technology
technical training

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The integrated system test for the Advanced Instructional System (AIS) was designed to provide quantitative answers regarding the training time reductions resulting from certain computer-managed instruction (CMI) functions of the AIS. The reliabilities of the CMI functions and of the AIS support systems (media, computer hardware, and software) were also investigated.

Testing established that conversion of the conventional lockstep Inventory Management (IM) course to self-pacing with basic CMI functions reduced training time by 35%. In the Material Facilities (MF) course, the reduction was 24%; in Precision Measuring Equipment (PME), 31%; and in Weapons Mechanic (WM), 31%. Student

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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progress management (SPM), an additional CMI capability which gives frequent feedback to the student and instructor regarding the student's progress toward a computer-generated target graduation date, resulted in additional savings of 10% in IM, 6.7% in MF, 5.1% in PME, and 13.5% in WM. Individualized instructional assignment (IIA), another CMI capability whereby a student is assigned to those alternative instructional treatments that are predicted to be best for that student, resulted in additional savings in the IM course—individualization in one–fourth of the course reduced the average time in course by 3%.

Reliability and maintainability data collected during the integrated system test indicated that the CMI support functions, the media devices and courseware, and the computer hardware and software met or exceeded AIS requirements.

The lessons learned during AIS development were extrapolated to provide estimates of courseware development times that should be realizable in converting conventional lockstep instruction to AIS computer-based instruction.

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# INTEGRATED SYSTEM TEST OF THE ADVANCED INSTRUCTIONAL SYSTEM

## I. INTRODUCTION

### Overview

This introductory section describes the goals of the Integrated System Test (IST) and presents background information on the Advanced Instructional System (AIS) program, its goals, characteristics, and functions. The two subsequent sections, Testing Prior to IST and Instructional Strategies Testing, describe the assessment of instructional strategies in each of the AIS courses. The fourth major section describes procedures and results of testing to establish the reliability and validity of other AIS computer-based instructional functions. The results of testing to establish functional performance capability, reliability, and maintainability of the AIS support systems (computer, peripherals, terminals, communications, software, and media devices and courseware) are reported in the fifth major section. Courseware development costs are addressed in the sixth section. The final section of this report presents conclusions and recommendations. Supplemental data and examples are included in the appendixes.

### General Description of Test

The AIS IST began in April 1977. Testing was oriented toward answering four primary questions:

1. What are the time savings when a conventional lockstep technical training course is converted to a self-paced Computer Managed Instruction (CMI) course?

2. What are the time savings when Individualized Instructional Assignment (IIA) is added to a self-paced CMI technical training course?

3. What are the time savings when Student Progress Management (SPM) is added to a self-paced CMI technical training course?

4. Do the computer-based CMI support functions, the media devices and courseware, and the computer hardware and software achieve satisfactory levels of functional performance, reliability, and maintainability?

The first of these questions was addressed by the acceptance tests for the AIS courses. The results of these tests are summarized in Section II of this report. Section III, Instructional Strategies Testing, presents the results relating to the second and third questions. Sections IV and V, Reliability and Validity of Other CMI Functions and Support System Testing, present the results relating to the fourth question.

The data collected in the Inventory Management (IM) course provided the most comprehensive test of the effectiveness of IIA. Data from the Weapons Mechanic (WM) and the IM courses provided the most comprehensive tests of the effectiveness of SPM. Due to low student entry rates in the Precision Measuring Equipment (PME) and Materiel Facilities (MF) courses, the conclusions that could be drawn from IST results in these two courses were limited.

## Background

In May 1973, a 4 1/2 year effort was initiated jointly by the Air Force Human Resources Laboratory Technical Training Division (AFHRL/TT), Air Training Command (ATC), Lowry Technical Training Center (LTTC), and the McDonnell Douglas Astronautics Company-St. Louis (MDAC) to develop, implement, and test the Air Force AIS.

The major objectives of the AIS program were twofold. Primary and most critical was the development of a computer-based, multi-media system for the administration and management of individualized technical training on a large scale. The second objective was the utilization of the AIS as a test bed for evaluating the cost-effectiveness of instructional innovations. The characteristics of the AIS as originally planned and as configured during IST are shown below.

AIS CHARACTERISTICS

| CAPABILITIES | ORIGINAL REQUIREMENTS | CONFIGURATION DURING IST |
|---|---|---|
| NO. OF COURSES | 3 | 4 |
| NO. OF STUDENTS PER DAY | 2100 | 3000* |
| TRAINING TIME REDUCTION | 25% | 40%** |
| (Equal or better performance/No increase in attrition) | | |

* If more terminals were added, the computer configuration could support 4500 students on a three-shift operation.

** 40% includes 31% for mainline CMI plus 13% of the remaining 69% (9% of the total) due to individualization (individualized instructional assignment).

HARDWARE

| COMPUTER | CDC CYBER 73-16 | |
|---|---|---|
| INTERACTIVE TERMINALS | 125 | 50 |
| MANAGEMENT TERMINALS | 9 | 10 |
| STUDENT CARRELS | 190 | 847 |
| MEDIA DEVICES | 500 | 500 |

MEDIA ALLOCATION

| | | |
|---|---|---|
| PRINTED MATERIALS | 55% | 60% |
| AUDIO/VISUAL PRESENTATION | 28% | 38% |
| CAI | 17% | 2% |

Development of the AIS was to proceed incrementally. Capabilities were implemented upon development and before the entire system was completed in order to take immediate advantage of training improvements and thereby achieve incremental payoffs. As development and implementation proceeded, some adjustments to the originally-planned AIS characteristics had to be made. Two goals not achieved at the time of IST were (a) the complete development of all courseware required for the AIS test bed courses and (b) implementation of on-line Computer Assisted Instruction (CAI). The software capability for CAI was, however, developed, and subsequent to IST a number of CAI lessons have been implemented. Some of the factors which necessitated adjustments to the original goals were

1. Competition between the development program per se and operational support requirements for implemented portions of AIS.

2. Major changes in course content during development which greatly exceeded the original Statement of Work allowance of no more than 40% during the life of the contract.

3. Inclusion of an additional course.

The four courses chosen for initial demonstration cover a wide range of student aptitudes and abilities, comprise 27% of the total load at LTTC, and represent a cross section of technical training.

AIS COURSES

| | COURSE LENGTH (WEEKS) | GRADUATES PER YEAR PROJECTED |
|---|---|---|
| INVENTORY MANAGEMENT (IM) | 7 | 3000 |
| MATERIEL FACILITIES (MF) | 6 | 900 |
| PRECISION MEASURING EQUIPMENT (PME) | 32 | 600 |
| WEAPONS MECHANIC (WM) | 13 | 2500 |
| | | 7000 |

During the AIS contract, the two major goals of AIS development were achieved:

1. The prototype AIS, incorporating state-of-the-art instructional technology, was implemented at the LTTC and met or exceeded contractual requirements for reducing training time.

2. The prototype AIS provides a capability for continued research and development (R&D) in the instructional technology area. Continued exploitation of this AIS capability can greatly enhance further R&D efforts in training technology and educational research.

A typical scenario for a student in an AIS-configured course begins with the preassessment test battery consisting of approximately 2 hours of aptitude and ability tests. Some tests are general and some are specific to the course, but all are designed to identify problem areas and to provide information to be used by the computer in making individualized assignments as the student progresses through the course. These tests are listed in Appendix A. The machine-readable preassessment test answer sheets and a student registration form are read by an AIS management terminal, and the information is stored in the central computer. The computer determines, and provides printouts of, the student's learning center and carrel assignment plus the assignment to the first lesson in the course (examples of various AIS computer-generated printouts are provided in Appendix B). The student studies the lesson until satisfied that the content is understood and then takes the prescribed lesson test. The student takes the completed test answer sheet to a management terminal, places it in the reader, and receives feedback consisting of a printed prescription which provides the test results (total score and objectives failed), assigns the next lesson to be studied, lists the resources required, and if the next assignment involves a change in learning centers, assigns the student to the next learning center and carrel. In making each assignment, the computer considers what lessons the student could study next, which alternative instructional treatment is best for the student (if alternates are available for the lessons being considered), and resource utilization

status. The resultant student assignment is either the best one for the student or, if resource considerations so dictate, a compromise which attempts to avoid bottlenecks because of availability of critical resources. Additionally, the student's first course assignment gives a target completion date for the initial block and for the entire course. The first assignment for each training day informs the student as to progress relative to the target date.

## Unique CMI Functions of the AIS

The AIS CMI functions include all of the standard capabilities such as test scoring and production of learning center rosters, student progress records, and course evaluation reports. In addition, two unique CMI functions are provided by the AIS. These are IIA and SPM. Both were designed to produce training time savings in addition to the savings realized through self-pacing and standard (baseline) CMI, and were the focus of the IST evaluations of time savings. These two AIS unique functions are described in detail below.

### Individualized Instructional Assignment

The IIA function is the AIS capability to assign alternative modules of instruction (strategies) for a lesson in order to maximize student performance. The vehicle for making these assignments is the AIS computerized adaptive decision process which considers the individual characteristics and past performance of the student (preassessment and within-course data), as well as the student's current placement in the course hierarchy and the availability of instructional resources.

The selection of the most appropriate module for a particular lesson and student can be made on the basis of (a) predictive statistics (regression models) based on the performance of prior students who were randomly assigned to the alternative modules for a lesson, (b) empirical and/or judgemental logical statements (heuristic models) which select a particular module if the conditions specified in the logical statement are true, and (c) student choice of available alternative modules (learner choice) which leaves the selection of the most appropriate module to the student's own judgement. A random assignment capability also exists for control purposes in evaluating and/or updating existing decision models. These lesson-level capabilities represent a range of sophistication in terms of their requirements for accurate student data and statistical computation. The regression models are the most sophisticated, followed by the heuristic models and learner choice.

Regression Models. The nature of this approach requires that the equations used to select alternative modules be based on sufficiently large samples of cases (e.g., 100 students per alternative module) collected under random assignment conditions. This insures that best fit equations can be calculated relating the full range of student characteristics (predictor variables) and student performance time or

score (criterion variables) on each module. The regression modules calculated from these data then become the basis for predicting which module will maximize individual student performance. It is imperative, therefore, that the regression models use data that are highly reliable and valid, as well as representative of conditions that exist when they are implemented. During the IST, regression models were used in the AIS IM and MF Courses.

Heuristic Models. Research and development for the AIS CMI system required the exploration of regression models for IIA. It became apparent to both MDAC and AFHRL/TT personnel, however, that the level of sophistication and computational requirements of this approach would make it difficult to maintain regression models in an operational training system. For this reason, an alternative approach was designed and developed. This approach, called heuristic models, refers to the specification and use of logical "if...then" statements to assign students to alternative modules. These logical statements can be based solely on expert judgement, on previously collected and analyzed student data, or on a combination of both judgement and prior data.

An example of a simple heuristic model can be written in sentence form as follows: "If the student has a Reading Vocabulary Test score less than 20, assign the audio-visual module for this lesson." Any combination of preassessment and prior within course performance data (subject to normal AIS variable limits and constraints) can be used in the construction of heuristic models.

During the IST, heuristic models were used for media overlap (i.e., audio-visual with illustrated script modules versus illustrated script only modules) lessons in the IM, MF, and WM courses. These models were based on a combination of expert judgement (instructor inputs) and prior student data on these modules.

Learner Choice. The third major type of lesson-level individualization capability allows the student to select one of the alternative modules on lessons designated for learner choice. Performance data are collected on the module the student selects. Over a period of time, it is possible to answer such questions as the effectiveness of student choices compared with the choices of regression or heuristic models, and what types of students make the most effective module choices in terms of maximizing their scores and minimizing their training times.

The literature appears to support the conclusion that learner choice is best for students of higher ability and intellectual maturity. For this reason and because (a) PME instructors and supervisors indicated that they would prefer this approach over the use of heuristic models and (b) insufficient data per alternative module were available from PME for the derivation of regression models, the learner choice approach to IIA was chosen for implementation and evaluation with PME course materials in Blocks VII through XI.

Student Progress Management

In addition to the above individualization approaches which are directed toward maximizing student performance at the lesson level, the AIS has a block and course-level CMI capability designed to further maximize student performance. This strategy, referred to as SPM, is operational in all four AIS courses.

The SPM monitors student rates of progress, predicts individual block and course completion time targets, and manages students to their individual targets via specialized instructional, administrative, and software tools. Additionally, the SPM assists students in achieving their potential by giving each an opportunity to assume responsibility for performing in accordance with individual abilities, interests, and prior experiences.

The following are the major components of SPM:

1. Targeted days in course and completion rates are predictions generated at the beginning of each course. These predictions provide information as to how many days each student is expected to require for course completion. The predictions are based on (a) information gathered on the student during preassessment testing, (b) the performances (times-to-complete) of similar students who have completed the same course, and (c) policies set by the course managers which determine minimum, maximum, and average desirable course completion times. Targeted course completion rate (an index of the student's relative speed) is derived from these predictions and is used to track daily progress.

2. An instructional module introduces students to the novel aspects of a CMI environment and includes instruction on some specific, AIS-related time management skills; for example, a method of tracking progress relative to the student's particular target date. This module became operational in the IM, MF, and WM courses in July 1977. Because of the longer blocks and the incremental implementation of SPM in the PME course, a special set of student and instructor SPM orientation materials was prepared for this course.

3. A daily roster (see Appendix B) is printed for instructors. The roster indicates the block each student is in, how many days the student has to finish the course on target, and how many days each student is ahead or behind targeted completion rate. The daily roster thus provides a mechanism whereby the instructors can track the progress of each student and identify those students who are behind their targeted rates and in need of counseling.

4. Via their first prescription of each day, students are provided with feedback regarding their actual progress versus their predicted progress (Appendix B). The feedback includes days spent in class and days of the course completed. If these numbers are identical, the stu-

dent is on schedule; if days spent in class is larger than days of course completed, the student is behind schedule. Conversely, if days of course completed is larger than days spent in class, the student is ahead of schedule. In addition, a student's first printed assignment in each new block of instruction provides targeted days per block information, based on the average length of the block and the student's individualized targeted completion rate.

5. Finally, provision has been made for instructors to adjust a student's targeted completion rate when such action is justified (e.g., if personal problems have interfered with the student's work).

## II. TESTING PRIOR TO IST

### Testing of Self-Pacing and CMI

When the AIS project began in 1973, the IM, MF, PME and WM courses were taught in a conventional lockstep classroom environment. One or two instructors were responsible for a class of from 20 to 30 students as they progressed through one block of instruction in a course. Blocks were 1 to 4 weeks in length, and after the prescribed number of weeks of study, the students took the end-of-block test. Those who passed went on as a class to the next block, and those who failed were "washed back" to a following class to repeat some or all of the block.

A good evaluation strategy would have been to freeze the content taught in the AIS courses, with known times-to-complete under conventional instruction, and then incrementally introduce manual self-pacing, then computer support, next IIA, and finally the student time management system. The effects of these features could then have been assessed incrementally, and system time savings could have been calculated with considerable confidence. The real world demands of Air Force training did not, however, permit such laboratory control. Economics, logistics, and training considerations dictated that AIS features should be implemented as they were developed. Some consequences were that

1. As soon as one track of self-paced materials for a block had completed formative evaluation, those materials were implemented in the classrooms and the conventional block was terminated.

2. As materials for AIS were being developed, content changes were incorporated. However, those same content changes were frequently never introduced into the conventional course. In other words, AIS development represented a convenient vehicle for accomplishing necessary changes to the conventional course content and materials.

3. Development efforts continued on AIS blocks after they were implemented--changes in content in response to the continuing changes in Air Force operational procedures and equipment, and the introduction of multi-tracking and media overlap lessons as needs were identified and development was accomplished.

4. Computer-based training features were introduced into the classrooms as the features were developed and then were tested, modified, and improved as time and circumstances permitted.

Therefore, in order to establish estimates of time savings for contractual purposes, a more pragmatic approach had to be adopted. Air Force subject matter experts identified those AIS lessons and parts of lessons which had the same content as that which had previously been taught in the conventional mode. For each course, time savings were calculated by comparing the time to complete this common core of material under AIS to the Plan of Instruction (POI) hours required under the previous conventional lockstep mode. These analyses were carried out during the acceptance tests for the AIS courses.

The IM acceptance test results indicated that the time savings from conversion of the conventional IM course to self-pacing with CMI amounted to 35%, based only on the material common to both the AIS and the conventional courses. The savings in the MF course were 24%; in the PME course, 31%; and in the WM course, 31%. The acceptance test results are summarized in Table 1.

TABLE 1. AIS Course Acceptance Testing: Estimates of Time Savings Due to Self-Pacing with CMI

| COURSE AND TIME PERIOD | TIME SAVINGS FROM SELF-PACING WITH CMI,% | PORTION OF COURSE USED IN TIME SAVINGS MEASUREMENT |
|---|---|---|
| IM<br>July 1975-June 1976 | 35 | 49% of Blocks I-II, IV-V |
| MF<br>July 1975-June 1976 | 24 | 64% of Blocks I-V |
| PME<br>August 1976-July 1977 | 31 | 38% of Blocks VIII-XII |
| WM<br>August 1976-July 1977 | 31 | 77% of Blocks V-XIII |

Some further explanation of these time savings figures is necessary. For example, the time savings recorded in the IM and MF Acceptance Tests were 35% and 24%, respectively. Since these figures are based on common material only, they are only estimates (albeit reasonable ones) of the total percent course length reduction attributable to AIS. Thus, the approximately 30% savings for IM/MF suggest that if an entire conventional course were to become self-paced with CMI, overall savings on the order of 30% would be expected if the course content was unchanged.

Later portions of this report establish that an additional 12.5% saving for IM is attributable to IIA and SPM. This saving relates to the course as it existed at the onset of the IST period, not to the original lock-step course. Thus, the 30% and 12.5% are not simply additive in terms of describing how much the course was shortened relative to what it was before AIS. However, the 12.5% is a tangible saving, over and above savings due to self-pacing and CMI.

## III. INSTRUCTIONAL STRATEGIES TESTING

### Testing of IIA and SPM

At the beginning of the IST, all blocks of the IM and MF courses were self-paced with CMI, as were Blocks VII through XII of PME and Blocks V through XIII of WM. The IM course had the most extensive set of individualized alternative modules and an entry rate of approximately 60 students per week. The MF course had a less extensive set of individualized alternative modules and an entry rate of about 20 per week. The PME course had individualized alternatives but a very low entry rate (about six per week on the AIS shifts). The WM course had only media overlap modules as alternatives to the main track of instruction and an entry rate of approximately 60 per week.

The baseline CMI condition for comparisons in the following sections includes principally the following functions:

1. Printed feedback of total score and objectives failed on tests.
2. Printed assignment to next lesson, including resources required.
3. Learning center rosters and individual student progress reports.
4. Resource management including learning centers, carrels, audio-visual devices and remote terminals.
5. Flagging for instructors those students whose preassessment results indicate potential learning problems.
6. Displaying or printing student course and preassessment records for instructor use in counseling.

7. Providing management reports (e.g. the Course Evaluation Summary).

Testing in the IM Course

At the start of the IST, two operating configurations were established in the IM course: (a) a Main Track version of the course and (b) an IIA version. Twelve weeks later, the SPM functions were added to the baseline CMI in the IM course. The IST design for IM is represented pictorially as follows:

| | Phase I Baseline CMI | Phase II CMI with SPM |
|---|---|---|
| Main Track | Group 1 | Group 3 |
| IIA | Group 2 | Group 4 |

0 Weeks 12 Weeks 20 Weeks

The main track of instruction was identified on a historical basis, with the first module developed being designated as Main Track. A student in the Main Track version was assigned the main track modules for all lessons in the course. A student in the IIA version was, for all lessons with alternative modules, assigned the best alternative for that student. "Best" was defined as the module for which the computer's calculations predicted a passing score in the shortest time; or if it was predicted that no module would be passed, the module predicted to be completed with the highest score. Students were assigned randomly to the Main Track and the IIA versions, and to a third version (random assignment to alternatives) which provided data for development purposes. Approximately 20 students per week entered each of the versions. Assignment to course learning centers was also random. Students were not told which version they were in, and instructors could only determine an individual student's assigned version by examining the student's records at an interactive terminal.

Four of the nine lessons in Block I, (approximately 32% of the block, based on average times to complete lessons) had two or more alternative modules. For Block II, 1 of 10 lessons (about 8% of the block) had alternatives; for Block III, 5 of 12 lessons (44%); Block IV, 3 of 9 lessons (35%); Block V, 3 of 12 lessons (18%); and in Block VI, none of the 9 lessons had alternatives. The two course versions, Main Track and IIA, operated in the IM course throughout the IST period.

During Phase I, students in both versions were under baseline CMI. After testing on each lesson or block, a student's test form was read at a management terminal and the student received a printed prescription containing test result feedback plus the next assignment. Main Track students were automatically assigned the main track modules. The IIA students were assigned the modules predicted to be best for them wherever alternatives existed. During system down times, learning center operations proceeded under manual management procedures, with main track assignments to all students except as resource availability required other modules to be used. The system was up during approximately 95% of the IST period.

Students who entered the course during Phase II were under the baseline CMI described above, plus SPM. After completing the preassessment test battery, each student received a computer-generated target completion date for the course. Students then studied a lesson designed to teach time management for meeting the target graduation date. Additionally, students were provided with charts on which to plot day-by-day progress toward the target. Each student's first prescription of each training day contained the information needed for chart update. The learning center rosters provided instructors with the number of days each student was ahead or behind target. Instructors were encouraged to use this information in counseling students. An instructor could adjust a student's target date if convinced that it was unrealistic.

During a 2-week period in Phase I, a software fault resulted in incorrect evaluations of the regression equations used in assignments for the IIA version. Consequently, data from the IIA version for this time period are excluded from the lesson and block level analyses. A data base error during 3 weeks of Phase II caused the IIA version for Block I to operate with incorrect information. Data from the IIA version of Block I for this time period are excluded from block and lesson level analyses.

Analyses and Results for the IM Course. Equivalence of the IM Groups - As a preliminary step it was essential to establish that the students of the four groups constituting the IST analysis did not differ significantly from one another. If one or more of the groups differed from the others in ability or other psychological variables (preassessment), time savings analyses would be contaminated. The hypothesis to be tested is that the four groups are not statistically different in terms of the preassessment measures. An efficient way to test this hypothesis is with a four-group discriminant analysis using all the preassessment variables simultaneously as discriminators. When this analysis was performed, none of the discriminant functions was significant ($p > .10$)*, indicating that the groups did not differ significantly with respect to preassessment measures.

* Throughout this report, results which reach the .10 level are described as statistically significant. This level was adopted in order to permit latitude in further considering potentially important effects.

Analyses of the IM Time Data - Block completion times, excluding absence times, are shown in Table 2. Students in the IIA version completed every block in less time than students in the Main Track version, except for Block IV in Phase II (SPM) and Block VI in Phase I, which show very small differences favoring Main Track. Block VI has no alternative modules, so students in the two versions received identical treatment in this block. Summing across the blocks with alternatives (Blocks I through V, see Table 2) indicates that IIA students averaged 437 minutes, or 4.7%, less time than the Main Track students in Phase I. This difference amounts to slightly more than one training day. In Phase II, IIA students averaged 166 minutes (almost a half day) less than Main Track students, for a savings of 2.1%. It should be stressed that these percentages are for Blocks I through V, and that only 30% of these blocks offered alternatives with a potential for savings due to IIA. Moreover, additional gains from IIA could be expected with further development of adaptive instructional alternatives and decision model refinements.

The comparisons of Phase I with Phase II (Table 2) indicate that the introduction of SPM resulted in a saving of 845 minutes for the IIA version (8.9%), and a saving of 1096 minutes (11.1%) for the Main Track version. The comparison of Phase I Main Track with Phase II IIA shows a total saving of 1264 minutes (12.8%).

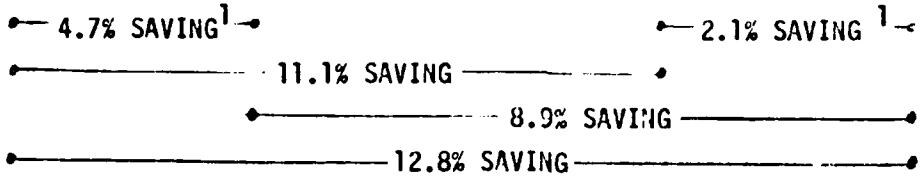
An additional variable, course elapsed time, was extracted and analyzed. Course elapsed time includes some administrative and testing time that is not in the sum of the block times, and includes only students who entered and completed the IM course during Phase I, or during Phase II. The results are shown in Table 3. Of principal interest here is a comparison of the Phase I Main Track version with the Phase II IIA version. In this comparison, the baseline condition is the self-paced IM course with CMI. The time savings achieved by adding computer assignment to individualized modules (for one-fourth of the course) and SPM to the baseline CMI course amount to 1255 minutes, or 12.4%.

To determine the statistical significance of these results, two-way analyses of variance were run on the time data for each of the blocks and on course elapsed time. Table 4 shows the significance levels for the main effects (IIA/Main Track and Phase I/Phase II) and for the interactions. The effects of SPM on time in Blocks I, II, III, and VI and on course elapsed time were significant. In Blocks IV and V, the SPM effects were in the expected direction, but did not reach significance. The IIA effects were significant in Blocks I and V. None of the interactions were significant.

In each of Blocks I to V, one-way analyses of variance were run on the sums of the lesson times for only those lessons with alternative modules. The results can be summarized as follows: In all blocks the differences were in the expected direction of shorter times for IIA students, but statistical significance was reached only in Block IV (IIA, 347

TABLE 2. Mean Block Times (Minutes) in the IM Course During IST, Excluding Absence Time

| BLOCK | PHASE I: BASELINE CMI | | | PHASE II: CMI WITH SPM | | |
|---|---|---|---|---|---|---|
| | MAIN TRACK | IIA | SAVED BY IIA,% | MAIN TRACK | IIA | SAVED BY IIA,% |
| I | 1467 (N=119) | 1383 (N=116) | 5.7 | 1262 (N=127) | 1156 (N=83) | 8.4 |
| II | 1775 (115) | 1725 (96) | 2.8 | 1548 (126) | 1528 (120) | 1.3 |
| III | 2455 (110) | 2315 (70) | 5.7 | 2073 (109) | 2051 (111) | 1.1 |
| IV | 1394 (115) | 1378 (87) | 1.1 | 1330 (103) | 1335 (125) | -0.4 |
| V | 1651 (122) | 1504 (74) | 8.9 | 1524 (85) | 1501 (114) | 1.5 |
| VI | 1144 (128) | 1162 (100) | N.A.[1] | 1053 (84) | 1051 (111) | N.A.[1] |
| TOTALS | 9886 | 9467 | --- | 8790 | 8622 | --- |




[1] Block VI had no alternative modules. Percent savings for IIA are based on Blocks I to V only.

TABLE 3. Mean Course Elapsed Times (Minutes) in the IM Course During IST, Excluding Absence Time

| PHASE I: BASELINE CMI | | | PHASE II: CMI WITH SPM | | |
|---|---|---|---|---|---|
| MAIN TRACK | IIA | SAVED BY IIA,% | MAIN TRACK | IIA | SAVED BY IIA,% |
| 10134 (N = 86) | 9870 (N=79) | 2.6 | 9217 (N=68) | 8879 (N=66) | 3.7 |

PHASE I MAIN TRACK VERSUS PHASE II IIA, 12.4% SAVINGS

TABLE 4. Significances of Results from Two-Way Analyses of Variance on Time Data from the IM Course.

$p > .10$ IS SHOWN AS N.S.

| | MAIN EFFECT A: IIA VS. MAIN TRACK | MAIN EFFECT B: BASELINE CMI VS. CMI WITH SPM | INTERACTION: A x B |
|---|---|---|---|
| BLOCK I TIME | $p < .10$ | $p < .01$ | N.S. |
| BLOCK II TIME | N.S. | $p < .01$ | N.S. |
| BLOCK III TIME | N.S. | $p < .01$ | N.S. |
| BLOCK IV TIME | N.S. | N.S. | N.S. |
| BLOCK V TIME | $p < .05$ | N.S. | N.S. |
| BLOCK VI TIME | N.S. | $p < .01$ | N.S. |
| COURSE ELAPSED TIME | N.S. | $p < .01$ | N.S. |

minutes; Main Track, 382 minutes).

Analyses of the IM Block Score Data - To determine the effects of IIA and SPM on first attempt scores on the end-of-block tests, two-way analyses of variance were run. In Blocks I, II, and III the baseline CMI/SPM main effects were significant, with SPM students scoring lower than the baseline CMI students. However, the largest single difference is for Main Track in Block II where SPM students averaged 79.9% and non-SPM students averaged 83.4%. In Block IV, the main effect of IIA was significant for block score with IIA scoring higher than Main Track (83.3% versus 81.7%).

Analyses of the IM Block Fail Rates - To determine the effects of IIA and SPM on first attempt block failures, chi-square analyses were used. There were no significant differences in any blocks.

Summary and Conclusions for the IM Course. The questions addressed by the IST analyses in IM are:

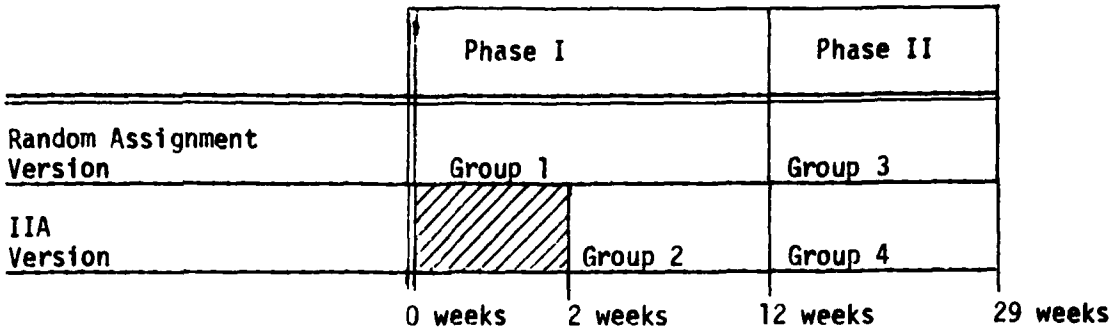
1. What are the student time savings if IIA is added to the baseline (Main Track with baseline CMI)?

2. What are the student time savings if SPM is added?

Under the conditions investigated in the IST, introducing IIA for one fourth of the IM course resulted in saving 2% to 4% of the total course length. The introduction of SPM resulted in saving 9% to 11% of total course length. The combination of IIA with SPM reduced course length by more than 12%. These gains are the result of superimposing IIA and SPM on a self-paced course with baseline CMI.

## Testing in the MF Course

Because of a lower student entry rate (20 per week), IST results in the MF course were not as conclusive as the results in the IM course. At the start of IST, all students in the MF course were under CMI with random assignment to alternative modules. Two weeks later, an IIA version was implemented. As those students in the course started a new block, they were randomly placed in either the IIA or the random assignment version of the course for their remaining blocks. Students entering the course subsequently were randomly assigned to one of the same two versions. After 12 weeks, the SPM functions were implemented in the MF course. The IST design for MF is represented pictorially as follows:




Implementation of the IIA version was delayed in order to use the additional random assignment data in deriving regression equations for IIA. A student in the Random Assignment version was, on lessons with alternative modules, assigned randomly to one of the available modules. A student in the IIA version was assigned to the best module, with "best" defined as for the IM course.

The extent of IIA in the MF course was as follows: in Block I, 5 of 9 lessons had alternative modules accounting for approximately 56% of block time; in Blocks II, III, and IV, respectively, 1 of 10, 1 of 9, and 1 of 12 lessons had alternatives accounting for approximately 10% of block times; and in Block V, 1 of 9 lessons, or 6%, had alternatives. The software fault and the data base error that invalidated some IM data had the same effects in the MF course, and the same exclusions were applied.

Analyses and Results for the MF Course. The groups in the MF analyses are relatively small, particularly in Phase II. Consequently, the results must be interpreted with caution. The only statistically significant time differences are the savings due to SPM in Blocks I, II, IV, and V, but larger sample sizes might have disclosed additional significant effects.

Equivalence of the MF Groups - Similar to the analyses used in IM, four-group discriminant analyses were run for each block using all pre-assessment variables as discriminators. None of the discriminant functions were statistically significant, indicating that the groups did not differ significantly with respect to preassessment measures.

Analyses of the MF Time Data - Block times, excluding absence times, are shown in Table 5. In four of the five blocks in Phase I, students in the Random Assignment condition took less time to complete than did students in the IIA version. The exception was Block III, where IIA students had the shorter time. Under the Phase II SPM condition, IIA students completed Blocks I and II in less time than did Random students, but took more time to complete Blocks III, IV and V. Summing across blocks to derive totals for Blocks I through V (Table 5) shows that in Phase I the Random students averaged 668 minutes less for the five blocks than did IIA students, a difference of 8.6%. In Phase

TABLE 5. Mean Block Times (Minutes) in the MF Course During IST, Excluding Absence Time

| BLOCK | PHASE I: BASELINE CMI | | | PHASE II: CMI WITH SPM | | |
|---|---|---|---|---|---|---|
| | RANDOM ASSIGNMENT | IIA | SAVED BY IIA,% | RANDOM ASSIGNMENT | IIA | SAVED BY IIA,% |
| I | 1483 (*N*=91) | 1852 (*N*=29) | -24.9 | 1359 (*N*=86) | 1325 (*N*=90) | 2.5 |
| II | 1975 (79) | 2185 (22) | -10.6 | 1799 (80) | 1792 (103) | 0.4 |
| III | 1941 (66) | 1900 (26) | 2.1 | 1804 (80) | 1947 (94) | -7.9 |
| IV | 1127 (79) | 1192 (27) | - 5.8 | 1043 (84) | 1053 (88) | -1.0 |
| V | 1224 (80) | 1289 (29) | - 5.3 | 1084 (74) | 1100 (88) | -1.5 |
| TOTALS | 7750 | 8418 | - 8.6 | 7089 | 7217 | -1.8 |

8.5% SAVING

14.3% SAVING

6.9% SAVING

II (with SPM) the Random students averaged 128 minutes less than the IIA students, a difference of 1.3%.

Comparisons of Phase I with Phase II indicate that, for the IIA version, the addition of SPM to the CMI functions of Phase I resulted in a saving of 1201 minutes, or 14.3%. In the Random version the data indicate a saving of 661 minutes due to SPM, or 8.5%. In the overall comparison, a 6.9% saving over Main Track Baseline CMI (random assignment) was realized by introducing IIA plus SPM (although IIA was not as good as random assignment).

Course elapsed time was also analyzed. This variable includes administrative and testing time that is not in the sum of the block times, and the data include only students who started and completed the course during Phase I, or during Phase II. The results (Table 6) indicate that, in Phase I, Random was better than IIA by 9.0%, but in Phase II, IIA was better than Random by 0.5%. Table 6 data further indicate that SPM resulted in saving 9.0% for IIA students and 0.4% for Random students. The overall comparison of Phase I Random with Phase II IIA shows that a 0.9% saving over baseline was realized by introducing IIA plus SPM.

To determine the statistical significance of these results, two-way analyses of variance were run on each of the block times and on course elapsed time. Table 7 shows the significance levels for the main effects and interactions. The main effect of SPM is significant in Blocks I, II, IV, and V. The two-way interaction is significant only for Block I.

Analyses of the MF Block Score and Block Fail Rate Data - Two-way analyses of variance were run on first attempt block scores, and chi-square analyses were run on numbers of first attempt block failures. None of the block failure differences and only one of the block score differences reach the .10 level of significance -- in Block II, the average block score under SPM is 4.1 points higher than under baseline CMI.

Summary and Conclusions for the MF Course. The data and analyses reported in Tables 5, 6, and 7 indicate that the very limited IIA in the MF course did not result in any statistically significant effects on either block times or course time. The effects of SPM are statistically significant in Blocks I, II, IV, and V, and course elapsed time shows the expected result of decreased time under SPM. From Tables 5 and 6, estimates of the savings attributable to SPM range from as low as 0.4% (Baseline CMI versus SPM, Random Assignment, course elapsed time) to as high as 14.3%. (Baseline CMI versus SPM with IIA, sums of the block times). The best overall estimate of savings due to SPM in the MF course may be 6.7%, the result of averaging the six estimates derived in Tables 5 and 6 (8.5%, 14.3%, 6.9%, 0.4%, 9.0%, and 0.9%; average = 6.7%).

TABLE 6. Mean Course Elapsed Times (Minutes) in the MF Course During IST, Excluding Absence Time

| PHASE I: BASELINE CMI | | | PHASE II: CMI WITH SPM | | |
|---|---|---|---|---|---|
| RANDOM ASSIGNMENT | IIA | SAVED BY IIA,% | RANDOM ASSIGNMENT | IIA | SAVED BY IIA,% |
| 7994 (N=42) | 8710 (N=22) | -9.0 | 7960 (N=84) | 7924 (N=92) | 0.5 |

0.4% SAVING

9.0% SAVING

0.9% SAVING

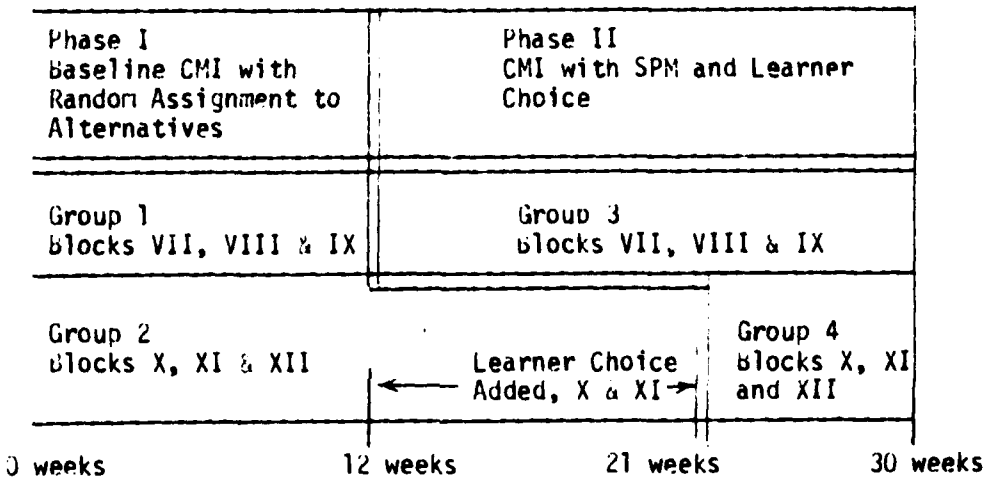
TABLE 7. Significances of Results from Two-Way Analyses of Variance on Time Data from the MF Course.

$p > .10$ is shown as N.S.

| | MAIN EFFECT A: IIA VS. RANDOM | MAIN EFFECT B: BASELINE CMI VS. CMI WITH SPM | INTERACTION: A x B |
|---|---|---|---|
| BLOCK I TIME | N.S. | $p < .01$ | $p < .01$ |
| BLOCK II TIME | N.S. | $p < .01$ | N.S. |
| BLOCK III TIME | N.S. | N.S. | N.S. |
| BLOCK IV TIME | N.S. | $p < .05$ | N.S. |
| BLOCK V TIME | N.S. | $p < .01$ | N.S. |
| COURSE ELAPSED TIME | N.S. | N.S. | N.S. |

## Testing in the PME Course

At the beginning of the IST, PME students were under CMI in Blocks VII to XII, with random assignment to the alternative modules. The small numbers of students entering the AIS PME course, about six per week, were not sufficient to support multiple test conditions. During Phase I, students were assigned randomly to alternative modules. Phase II began with the introduction of Learner Choice in Blocks VII-XI on lessons with alternative modules and the introduction of a limited form of SPM in Blocks VII-IX. SPM was implemented in Blocks X-XII in Week 22. The IST design for PME is represented pictorially as follows:




By block, the numbers of lessons with alternative modules and the total numbers of lessons in the blocks were: Block VII, 4 of 30; Block VIII, 4 of 39; Block IX, 3 of 36; Block X, 7 of 47; Block XI, 1 of 47; and Block XII, none of 16. Other lessons in the course had alternative modules, developed either for second attempt remediation or for exceptional students, and assigned only by instructors. During IST, the Learner Choice function was not used for these lessons.

Under Learner Choice, the student prescriptions assigned the student's next lesson and recommended one module (based on resource considerations), but added that other modules were available and could be studied instead. The limited SPM that was implemented in the PME course included days ahead or behind target on the students' first prescriptions of each day, and on the instructors' daily roster printouts. Unlike the full SPM in the IM course, however, students did not receive the lesson on time management in self-paced courses and did not plot their daily progress.

Analyses and Results for the PME Course. Because of the low student entry rate (six students per week) and the length of the course (nominally 30 weeks), the testing that could be accomplished in the PME course was limited. In Blocks VII, VIII, and IX, where learner choice and SPM were added to Baseline CMI in Week 13, the block times, scores and fail rates, and the lesson times for learner choice lessons in Phases I and II were analyzed. In Blocks X and XI, where learner choice was added in Week 13 and SPM was added in Week 22, preliminary analyses indicated that learner choice had no significant effects on block times, scores or fail rates. Therefore, the IST analyses reported for these blocks treat the first 21-week period as Phase I, and the final 9-week period as Phase II. In Block XII, with no learner choice lessons, Phase II is the final 9 weeks.

Equivalence of the PME Groups - Similar to the analyses used in IM, two-group discriminant analyses using all preassessment variables simultaneously as discriminators were run. None of the discriminant functions were statistically significant. In other words, it cannot be asserted statistically that the groups differ with respect to preassessment measures.

Analyses of the PME Time Data - The mean block times for the AIS blocks are shown in Table 8. Block times decrease under SPM for Blocks VII, IX, X, and XII; time in Block VIII is essentially the same under SPM and under Baseline CMI; and time in Block XI is slightly increased under SPM. One-way analyses of variance indicate that the time differences in Blocks X and XII are statistically significant. Overall, the totals of the mean block times for Blocks VII-XII (Table 8) indicate that the Phase II conditions resulted in a 5.1% time saving.

Data on course elapsed times in Phases I and II were not available from the IST because of the length of the course.

Analyses of the PME Block Score and Fail Rate Data - One-way analyses of variance were run on first attempt block scores in Blocks VII-XII. In all blocks, scores were somewhat higher under the Phase II SPM condition. The differences ranged from a 0.1% increase in the average first attempt score in Block XI to a 4.9% increase in Block X. However, these differences were statistically significant only in Blocks VII and X.

Chi-square analyses of first attempt block fail rates in Blocks VII-XII indicated only one significant difference: first attempt fail rate in Block X dropped from 18.8% in Phase I to 4.5% in Phase II.

Analyses of the Effects of Learner Choice in PME - In addition to the block-level analyses described above, lesson-level analyses were carried out on the times to complete the learner choice lessons only. Table 9 summarizes the results of these analyses. Only the Block IX difference is significant. Comparisons of the learner choice lesson

TABLE 8. Mean Block Times (Minutes) in the PME Course During IST.
Block Times are Corrected for Absence Times

| BLOCK | PHASE I: BASELINE CMI, RANDOM ASSIGNMENT | | PHASE II: SPM & LEARNER CHOICE | | SAVED BY PHASE II CONDITIONS,% |
|---|---|---|---|---|---|
| VII | 4833 | (N=71) | 4725 | (N=64) | 2.2 |
| VIII | 5000 | (65) | 5017 | (60) | -0.3 |
| IX | 4105 | (68) | 3935 | (61) | 4.1 |
| X | 4384 | (101) | 3753* | (44) | 14.4 |
| XI | 4270 | (108) | 4426 | (35) | -3.7 |
| XII | 2010 | (123) | 1487** | (145) | 26.0 |
| TOTALS: | 24602 | | 23343 | | 5.1 |

* $p < .05$, Phase I time vs. Phase II time

** $p < .01$, Phase I time vs. Phase II time

TABLE 9. Mean Times (Minutes) to Complete Only the Learner Choice Lessons in the PME Course

| BLOCK | NUMBER OF LESSONS INCLUDED | MEAN TIME TO COMPLETE ALL INCLUDED LESSONS | | SAVED BY PHASE II CONDITIONS,% |
|---|---|---|---|---|
| | | PHASE I | PHASE II | |
| VII | 3 | 509 (N=55) | 499 (N=68) | 2.0 |
| VIII | 4 | 615 (33) | 610 (35) | 0.8 |
| IX | 2 | 174 (53) | 197* (51) | -13.2 |
| X | 7 | 663 (41) | 672 (20) | - 1.4 |
| XI | 1 | 76 (89) | 80 (33) | - 5.3 |
| BLOCKS VII-XI | 17 | 2037 | 2058 | - 1.0 |

* $p < .10$, Phase I time vs. Phase II time

time differences in Table 9 with the block time differences in Table 8 indicate that learner choice did not account for a substantial part of any of the block time differences.

Summary and Conclusions for the PME Course. Learner choice did not significantly affect block times in the PME course. However, the numbers of cases analyzed are not sufficient to provide definitive answers as to the effectiveness of learner choice as an instructional strategy.

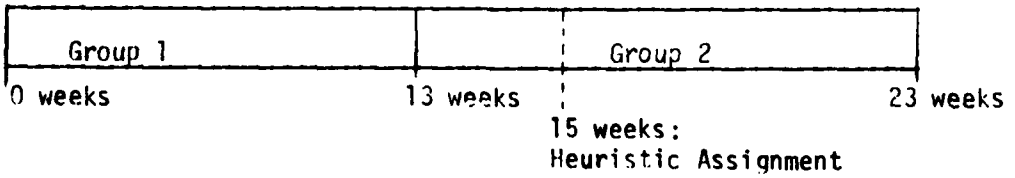
The introduction of SPM, even in the limited form implemented in the PME course, appeared to result in approximately 5% reduction in training time. However, the number of cases was relatively small, and this effect reached statistical significance only in Blocks X and XII. Additional savings should result from implementing full SPM and from improving administrative procedures to further exploit the feedback provided by SPM.

Testing in the WM Course

During Phase I of the IST in the WM course, students were randomly assigned by the baseline CMI System to the alternative modules in the AIS Blocks V to XIII. Phase II began when the SPM functions were introduced in Blocks I to XIII. The IST design for WM is represented pictorially as follows:

Phase I: Baseline CMI, Random Assignment to Alternatives

Phase II: CMI with SPM




The main track development in WM placed heavy emphasis on audio-visual (A/V) modules. The only alternative materials utilized in the WM course during IST were black-and-white printed versions of the A/V modules, or combinations of the A/V and the printed materials. These alternatives had been developed only as a printed backup to the main track A/V modules, and were not designed and developed specifically to facilitate learning for a subset of students. Therefore, the conditions in the WM course could not be viewed as a test of the effects of IIA. Logical assignment rules (heuristics) for assigning students to the A/V or printed alternatives were introduced in Week 16.

The principal IST effort in the WM course was directed toward

determining the effects of the SPM functions of the system. The course operated through Phase I under the baseline CMI system, i.e., self-paced with all of the regular CMI features of scoring by total score and by objective, assignment to lessons, rosters, resource management and reports, and with random assignment to alternatives. In Phase II, the lesson on how students should manage their time and efforts in order to succeed in a self-paced environment was introduced at the beginning of the course. The individual charts, on which students plotted progress toward a targeted graduation date (derived by the computer and based on preassessment test scores), were also implemented. Instructors were briefed on the meanings and uses of the SPM information which was printed out on their learning center rosters and were encouraged to use the information in counseling students who were falling behind.

Analyses and Results for the WM Course. Equivalence of the WM Groups - Similar to the analyses in IM, two-group discriminant analyses using all the preassessment variables simultaneously as discriminators were performed for the Phase I/Phase II groups for each block and for the course. The analyses indicated that the groups were significantly different with respect to the preassessment measures. The trend was toward higher ability students in Phase II. Therefore, analysis of covariance was used in the subsequent analyses of block and course times and block scores. The covariates in each analysis were the five preassessment variables which, in the discriminant analysis, were found to be the most important discriminators for the block or the course.

Analyses of the WM Time Data - Block times, corrected statistically for preassessment differences, are shown in Table 10. The Phase II conditions (SPM and heuristic assignment) result in time savings of more than 5% in every block except Block VII. Overall, the time saving for Blocks V through XIII was 13.9%. The analyses of covariance indicated all of the time differences shown in Table 10 were significant.

Course elapsed time in Phase I averaged 15,800 minutes, and in Phase II averaged 13,192 minutes. The saving in course elapsed time was 16.5%. Course elapsed time includes Blocks I to IV, which were not fully under CMI until Week 16. Some of the difference between the 13.9% saving realized in Blocks V to XIII and the 16.5% saving realized for the course can be attributed to new materials introduced into Blocks I to IV by ATC during Phase II of the IST.

In order to assess the effects of introducing the logical assignment rules (heuristics) during Phase II, the mean lesson times for only those lessons with logical assignment rules were analyzed. None of these lesson times showed significant decreases after the introduction of the assignment rules. Thus, the Phase II time savings cannot be attributed to the heuristic assignment rules.

Analyses of the WM Block Score and Fail Rate Data - Because of the marked time savings achieved in Phase II, the first attempt block

TABLE 10. Mean Block Times (Minutes) in the WM Course During IST, Excluding Absence Time and Corrected for Preassessment Differences

| BLOCK | PHASE I: BASELINE CMI RANDOM ASSIGNMENT | PHASE II: SPM WITH HEURISTICS | SAVED BY PHASE II CONDITIONS,% |
|---|---|---|---|
| V | 1896 (N=532) | 1637** (N=446) | 13.7 |
| VI | 1719 (535) | 1416** (292) | 17.6 |
| VII | 477 (531) | 508** (438) | -6.5 |
| VIII | 2019 (461) | 1913* (290) | 5.3 |
| IX | 981 (450) | 751** (135) | 23.4 |
| X | 973 (462) | 851** (139) | 12.5 |
| XI | 1257 (483) | 1040** (195) | 17.3 |
| XII | 1091 (459) | 892** (148) | 18.2 |
| XIII | 902 (465) | 731** (118) | 19.0 |
| TOTALS | 11315 | 9739 | ---- |
| ← PHASE II SAVING, 13.9% → | | | |

* $p < .05$ for Phase I vs. Phase II difference

** $p < .01$ for Phase I vs. Phase II difference

scores and the first attempt block fail rates were examined in detail. Table 11 summarizes these data. The scores were higher during Phase I in Blocks V, VI, and X; higher during Phase II in Blocks VIII, IX, XI, XII, and XIII; and equal in the two phases in Block VII. Across Blocks V to XIII, first attempt block scores average 80.1% during Phase I and 80.4% during Phase II. Analyses of covariance indicated that the score differences were statistically significant in Blocks VI, IX, XI, XII, and XIII. In the remaining blocks, the differences were not significant.

First attempt block fail rate data are summarized in Table 11. Chi-square analyses indicated that the differences in Blocks VI, VIII, X, and XI were significant, as were the differences in Blocks IX and XIII. Unlike the block time and block score analyses, however, the analyses of block fail rates were not adjusted for preassessment differences.

Summary and Conclusions for the WM Course. The introduction of full SPM functions in the WM course resulted in very substantial reductions in block and course times, with some detectable but probably not practically significant increases in block scores and decreases in first attempt block fail rates. Savings amounted to a 13.9% reduction in total time for Blocks V through XIII. The analyses indicate that little, if any, of this time saving can be attributed to the introduction of logical assignment rules for some of the media overlap lessons in the course. As a result, virtually the entire 13.9% saving must be attributed to the addition of the SPM functions to the CMI system.

## Student Attitude Data

Each student in the AIS courses during IST completed a 40-item attitude questionnaire at the end of the first AIS block of instruction and again at the end of the course. This questionnaire was intended to determine how students reacted to various features of the AIS courses. The results from these questionnaires are included as Appendix C to this report and reflect generally favorable attitudes toward the AIS courses.

## Training Time Savings From IIA and SPM

In the IM course, many of the alternative modules were developed using state-of-the-art educational research and development methods. Some alternatives, however, were developed to fill pressing and immediate needs and were designed without benefit of statistical analyses to guide the design toward a target subgroup of students. Nevertheless, savings of 4.2% in Phase I and 1.9% in Phase II suggest that 3% is a reasonable estimate of the time saved in IM due to IIA. This 3% was realized through application of IIA for only 27% of the course.

TABLE 11. Mean First Attempt Block Scores and First Attempt Block Fail Rates in the WM Course During IST

| BLOCK | BLOCK SCORE, % | | BLOCK FAIL RATE, % | |
|---|---|---|---|---|
| | PHASE I | PHASE II | PHASE I | PHASE II |
| V | 78.0 | 77.2 | 3.5 | 3.1 |
| VI | 80.8 | 78.1*** | 4.4 | 7.3* |
| VII | 86.5 | 86.5 | 2.0 | 1.5 |
| VIII | 74.6 | 74.8 | 10.6 | 6.9* |
| IX | 81.7 | 83.7** | 6.1 | 1.9** |
| X | 82.2 | 81.3 | 6.0 | 2.8* |
| XI | 80.7 | 82.4*** | 7.1 | 3.6* |
| XII | 75.6 | 76.7*** | 22.5 | 17.6 |
| XIII | 80.8 | 82.5** | 8.3 | 3.5** |
| MEANS, BLOCKS V-XIII | 80.1 | 80.4 | 7.8 | 5.4 |

* $p < .10$ for Phase I versus Phase II
** $p < .05$ for Phase I versus Phase II
*** $p < .01$ for Phase I versus Phase II

The introduction of SPM into the IM course resulted in time savings of 8.9% for IIA students and 11.1% for main track students. Assuming that the average of these two figures is the best available estimate of the time savings due to SPM, then the resultant net estimate is 10.0%.

The overall measure of IM time savings, derived by comparing the baseline CMI course (Phase I Main Track) with the full CMI-SPM course (Phase II IIA), is 12.8%. After adopting some compromise values for percent savings, Table 12 shows the time savings attributable to IIA and SPM in the IM course. The following assumptions entered into the calculations for Table 12 entries:

1. IIA saved 3%, SPM saved 10% and the combination of IIA and SPM saved 13%.

2. The IM course graduates 2820 students per year (60 students per week entry for 50 weeks with 6% attrition).

3. Baseline length for the IM course is 168 hours (the average course elapsed time for Phase I Main Track students).

4. A student-year in the IM course has 1440 in-class training hours (forty-eight 5-day weeks with 6 in-class hours per day = 1440 hours).

As indicated in Table 12, the result of IIA is a saving of almost 10 student years per year of course operation; the result of the SPM functions is a saving of more than 32 student years per year; and the total is more than 42 student years saved per year.

Table 13 shows the savings attributable to SPM in the MF course. The following assumptions were made:

1. The SPM functions saved 6.7%.

2. The MF course graduates 940 students per year (20 students per week entry for 50 weeks, with 6% attrition).

3. Baseline length for the MF course is 139 hours (the average course elapsed time for Phase I students).

4. A student year in the MF course has 1440 in-class training hours (forty-eight 5-day weeks with 6 in-class hours per day = 1440 hours).

As indicated in Table 13, the result of SPM is a saving of 6.1 student years per year of course operation.

In the PME course, SPM resulted in a 5.1% time savings. Table 14 shows the yearly savings attributable to SPM in the PME course. The

TABLE 11. Mean First Attempt Block Scores and First Attempt Block Fail Rates in the WM Course During IST

| BLOCK | BLOCK SCORE, % | | BLOCK FAIL RATE, % | |
|---|---|---|---|---|
| | PHASE I | PHASE II | PHASE I | PHASE II |
| V | 78.0 | 77.2 | 3.5 | 3.1 |
| VI | 80.8 | 78.1*** | 4.4 | 7.3* |
| VII | 86.5 | 86.5 | 2.0 | 1.5 |
| VIII | 74.6 | 74.8 | 10.6 | 6.9* |
| IX | 81.7 | 83.7** | 6.1 | 1.9** |
| X | 82.2 | 81.3 | 6.0 | 2.8* |
| XI | 80.7 | 82.4*** | 7.1 | 3.6* |
| XII | 75.6 | 76.7*** | 22.5 | 17.6 |
| XIII | 80.8 | 82.5** | 8.3 | 3.5** |
| MEANS, BLOCKS V-XIII | 80.1 | 80.4 | 7.8 | 5.4 |

* $p < .10$ for Phase I versus Phase II
** $p < .05$ for Phase I versus Phase II
*** $p < .01$ for Phase I versus Phase II

TABLE 12. Time Savings Per Year Attributable to IIA and SPM in the IM Course

| CMI FUNCTION | SAVING ,% | TRAINING HOURS SAVED PER STUDENT$_1$ | TRAINING HOURS SAVED PER YEAR$_2$ | STUDENT TRAINING TIME SAVED PER YEAR$_3$ |
|---|---|---|---|---|
| IIA | 3.0 | 5.04 | 14212 | 9.9 |
| SPM | 10.0 | 16.80 | 47376 | 32.9 |
| TOTALS | 13.0 | 21.84 | 61588 | 42.8 |

1. Training hours saved per student = Course length (168 hours) x % Saving.

2. Training hours saved per year = Training hours saved per student x Number of students per year (2820).

3. Student years saved per year = Training hours saved per year - Number of training hours per student year (1440).

TABLE 13. Time Savings Per Year Attributable to SPM in the MF Course

| SAVINGS,% | TRAINING HOURS SAVED PER STUDENT$_1$ | TRAINING HOURS SAVED PER YEAR$_2$ | STUDENT TRAINING TIME SAVED PER YEAR$_3$ |
|---|---|---|---|
| 6.7 | 9.31 | 8751 | 6.1 |

1. Training hours saved per student = Course length (139 Hours) x % Saving.
2. Training hours saved per year = Training hours saved per student x Number of students per year (940).
3. Student years saved per year = Training hours saved per year - Number of training hours per student year (1440).

TABLE 14. Time Savings Per Year Attributable to SPH in the PME Course

| SAVINGS, % | TRAINING HOURS SAVED PER STUDENT[1] | TRAINING HOURS SAVED PER YEAR[2] | STUDENT TRAINING TIME SAVED PER YEAR[3] |
|---|---|---|---|
| 5.1 | 20.91 | 5645 | 3.9 |

1. Training hours saved per student = Course length (410 Hours) x % Saving.

2. Training hours saved per year = Training hours saved per student x Number of students per year (270).

3. Student years saved per year = Training hours saved per year - Number of training hours per student-year (1440).

following assumptions were made:

1. The SPM functions saved 5.1%.

2. The PME course graduates 270 students per year from A and B shifts (six students per week entry for 50 weeks with 10% attrition).

3. Baseline length for the AIS portion of the PME course, Blocks VII to XII, is 410 hours (average time for Phase I students to complete Blocks VII to XII).

4. A student year in the PME course has 1440 in-class training hours (forty-eight 5-day weeks with 6 in-class hours per day = 1440 hours).

As indicated in Table 14, the result is a saving of 3.9 student years per year of course operation.

In the WM course, SPM resulted in a 13.9% time savings in Blocks V to XIII. Table 15 shows the savings attributable to SPM in the WM course. The following assumptions entered into the calculations for Table 15 entries:

1. The SPM functions save 13.5%.

2. The WM course graduates 2820 students per year (60 students per week entry for 50 weeks, with 6% attrition).

3. Baseline length for the WM course, Blocks V to XIII, is 188 hours (average time for Phase I students to complete these blocks).

4. A student year in the WM course, Blocks V to XIII, has 1920 in-class training hours (forty-eight 5-day weeks with 8 in-class hours per day = 1920).

As shown in Table 15, if only Blocks V to XIII are considered, SPM results in saving more than 38 student years per year of course operation. Assuming that the 13.9% savings measured in the upper blocks also applies in Blocks I to IV, then SPM would save an additional 10.8 student years per year. The total savings in student time for the WM course would then be approximately 49 student years per year of course operation.

The combined gains, from IIA and SPM in the IM course and from SPM in the MF course, in Blocks VII to XII of the PME course, and in Blocks V to XIII of the WM course, are 91.2 student years per year. The total gains, if the estimate for WM Blocks I to IV is also included, are 102.1 student years per year.

TABLE 15. Time Savings Per Year Attributable to SPM in the WM Course

| BLOCKS | SAVING,% | TRAINING HOURS SAVED PER STUDENT[1] | TRAINING HOURS SAVED PER YEAR[2] | STUDENT TRAINING TIME SAVED PER YEAR[3] |
|---|---|---|---|---|
| V-XIII | 13.9 | 26.13 | 73686 | 38.4 |
| I-IV | 13.9 | 5.56 | 15679 | 10.9 |
| TOTALS I-XIII | 13.9 | 31.69 | 89365 | 49.3 |

1. Training hours saved per student = Course length (188 hours, Blocks V-XIII; 40 hours, Blocks I-IV) x % Saving.

2. Training hours saved per year = Training hours saved per student x Number of students per year (2320).

3. Student years saved per year = Training hours saved per year - Number of training hours per student-year (1920, Blocks V-XIII; 1440, Blocks I-IV).

## IV. RELIABILITY AND VALIDITY OF CMI FUNCTIONS

### Reliability of Scoring and Storing Preassessment Data

Each student who enters an AIS course completes an AIS registration form and answers a battery of preassessment tests on AIS generalized test forms. The registration forms are read by a management terminal and the data they contain are used to establish individual, computerized Student Data Profiles (SDPs). Each SDP includes the student's name; social security number; date of birth; sex; formal civilian education completed; whether U.S. or foreign military or civilian; if military, the branch of service, status and grade; training squadron; type of student (e.g., non-prior service enlistee); date arrived on base; course attending; date training started; and training shift. Additionally, the student's preassessment test forms are read by the terminal, scored according to keys maintained in the computer, and the results stored as part of the student's individual SDP. The SDP is then used in the CMI system to make alternative module assignments and course completion predictions for the student. The SDPs are also available to course instructor and supervisory personnel for counseling purposes, and to management personnel for analyzing such factors as how well students of differing abilities are able to perform in the course. It is, therefore, essential to effective performance of AIS CMI functions that registration and preassessment data be correctly read, scored, and stored.

#### Procedure

During the IST, five student-completed sets of forms (one registration and four preassessment forms per student) were collected from each of the four AIS courses (IM, MF, PME, and WM). The student-entered data on the 20 registration forms were transcribed manually to listing sheets and, after correcting mechanical errors made by the students (partially marked responses or incomplete erasures), the forms were read at the management terminal. Then, the resulting computer-stored SDPs were displayed at an interactive terminal and the registration data were transcribed manually to the listing sheets. An item-by-item comparison was made between data transcribed from the registration forms and data transcribed from the SDP.

The student-entered data on the 80 preassessment forms were transcribed manually to listing sheets, with each preassessment scale or subscale being manually scored. After correcting mechanical errors made by the students, the forms were read at the management terminal. The resulting SDPs were displayed at an interactive terminal and the preassessment data were transcribed manually to the listing sheets. An item-by-item comparison was made between the responses and scores derived manually from the forms and the responses and scores stored in the SDP.

## Results

For the samples of 20 registration forms and 80 preassessment forms, the data from manual transcription and scoring corresponded 100% with the data stored in the SDP. Scoring and storing of AIS preassessment and registration data are reliable.

## Predictive Validity of Preassessment

A major purpose of AIS preassessment testing is to provide data on student characteristics which can be used by the CMI system in making alternative module assignments and in predicting progress in the course. The assignments and the predictions are based on heuristic decision rules or on regression equations derived through analyses of preassessment and within course data. There are two primary questions regarding the predictive validity of the preassessment tests. First, is each of the preassessment tests used in one or more of the assignment or prediction equations or rules? Second, do those equations or rules result in correct assignments or predictions? This section of the IST was concerned only with the first of these questions. The second, validity of the equations, is the subject of Section III of this Report.

## Procedure

A complete listing of all the assignment and prediction equations or rules, along with the specific use of each equation or rule, was obtained for each AIS course. These listings were sorted and transcribed to produce a listing showing, for each scale or subscale score derived from the preassessment test batteries, the locations and uses made of those scores by the CMI system.

## Results

All preassessment tests, with the exception of the Delta Biographical test, were used in one or more of the assignment rules or prediction equations (see Appendix A for a listing of preassessment tests). Frequencies of occurrence in the rules or equations for the various preassessment scores ranged from a single usage up to 37 separate occurrences.

## Reliability of Scoring and Storing Within Course Test Results

Within course testing in AIS includes three general categories: lesson tests, block tests, and student attitude questionnaires. Students mark their responses on machine-readable test forms. These forms are read at the management terminal and the results (item responses or scores) are stored in the student's SDP. The lesson and block test results are used in the CMI system to make pass/fail decisions and to predict time and score for subsequent lessons and blocks. Student attitude data are used in periodic reports on attitudes toward AIS

materials and procedures. The results of within course testing are available to course personnel for counseling purposes, for judging the effectiveness of course materials, and for detecting shifts in student attitudes and performances. These tests must be correctly scored, and the results properly stored, if the AIS CMI system is to perform its functions adequately and correctly.

## Procedure

During the IST, two student-completed block test forms were obtained from daily course transactions for each of the AIS block test versions in use. The block test forms in the samples were submitted at the management terminal to obtain the resultant student prescriptions. Each form was scored manually for total score and for failed objectives, and these data were transcribed to listing sheets. Item responses were compared directly with the computer-produced data on the corresponding printed prescriptions.

Twenty student-completed lesson test forms that included at least one form from each of the AIS blocks were drawn from daily operations in the four AIS courses. The 80 lesson test forms in the samples were scored manually for total score and for failed objectives and these data were transcribed to listing sheets. Item responses were again compared with the computer produced data on the printed prescriptions.

Student attitude questionnaires are administered at two points in the IM, MF, PME, and WM courses. A sample of five student-completed forms was obtained from each of these administrations and the responses from the resultant 40 forms were transcribed to listing sheets.

The SDPs were displayed at an interactive terminal, and the block, lesson, and attitude test data were transcribed manually to the listing sheets.

## Results

The comparisons of manually derived data with computer-stored and printed SDP data for the 80 lesson and 40 attitude forms indicated 100% correspondence for all items and scores.

During comparisons of manually derived data with SDP data for the block test forms, a number of discrepancies were observed. It was determined that the software routines supporting block test regrading were utilizing lesson level coding and thus creating erroneous objectives-failed data at the block level in the SDPs. As a result, necessary software corrections were made and replacement samples of block test forms were obtained and processed. The replacement samples all yielded 100% correspondence between manually derived and computer-produced SDP data.

## Validity of Within Course Tests

The AIS within course lesson and block tests were constructed using procedures oriented toward achieving content validity. Within course tests were developed by, or with the cooperation and assistance of, subject-matter specialists. Additionally, the tests were implemented only after the subject matter specialists agreed that the test questions adequately sampled the content being taught in the block or lesson. The nature of the AIS test development process insured that the tests had content validity. Consequently, the IST did not include testing of within course test validity.

## Reliability and Validity of the Course Data Base

The Course Data Base is a set of files containing records which provide all of the course characteristics and course configuration information necessary for the CMI system to correctly perform its student and resource management functions. The Course Data Base consists of the following files and records:

1. Course File - One record for each version of a course.
2. Course Hierarchy File - One record for each version of a course, for each block, and for each lesson group.
3. Lesson File - One record for each lesson and each module.
4. Cross Reference File - One record for each course and each block.
5. Test Key File - One record for each test.
6. Learning Center File - One record for each learning center on each shift.
7. Resource Class File - One or two records for each learning center on each shift.
8. Resource Type Descriptor File - One record, covering all courses.
9. Calendar File - One record for each course version.
10. Variables Definition File - one record for each variable defined to the system.

Timely and accurate maintenance of the Course Data Base is critical, and is the responsibility of the Air Force Data Base Managers designated for each of the AIS courses. The files are accessed, for display or modification, through appropriate editors at an interactive terminal.

Errors in the Course Data Base can result in incorrect student assignments, incorrect resource management, incorrect student performance data, and/or inefficient system performance.

## Procedure

The following samples from the Course Data Base Files were selected for inclusion in this test:

1. Course File records - Version 1 from IM, MF, PME, and WM.
2. Course Hierarchy File records - IM Block II, MF Block III, PME Block VIII, and WM Block VII.
3. Lesson File records - Five lessons and their corresponding module records from each course.
4. Cross Reference File records - IM Block II, MF Block III, PME Block VIII, and WM Block VII.
5. Test Key File records - (Testing accomplished under "Reliability of Scoring and Storing Within-Course Test Results.")
6. Learning Center File records - One learning center on one shift from each course.
7. Resource Class File records - One or two records (as required) for one learning center on one shift in each course.
8. Resource Type Descriptor File record - All types applicable to each course.
9. Calendar File records - Version 1 Shift 1 from each of the courses.
10. Variables Definition File records - Four variables from each course and four variables common to all courses.

## Results

Approximately 50 record segments, averaging 15 items of information per segment, were examined for each of the AIS courses. For the 3000 items of information (50 segments x 15 items x 4 courses) examined, only two discrepancies were identifed. In the Block VII Hierarchy File record for WM, the students per shift count did not agree with the number of students in the learning center. In the Resource Class File record for WM, the number of available resources (21) did not agree with the number of assignable resources (20). Both discrepancies were determined to be the result of clerical errors in establishing the data base and were corrected. Based on the sample results, two incorrect out of 3000 items

examined, the Course Data Base is 99.9% correct.

## Reliability of Student Prescriptions

Student prescriptions are the printed outputs from the management terminals which give AIS students their next assignments. In order to issue a reliable prescription, the CMI system must correctly determine the student's current position in the course; read and evaluate the student's current input (the test form which initiates the prescription process); determine which lesson or lessons can be taken next (i.e., which lessons are enabled); determine which of the enabled lessons have available resources (i.e., which lessons are feasible); and select and print the assignment. The prescriptions issued by the management terminals are reliable if they assign students to enabled and feasible lessons.

### Procedure

During the IST, 100 prescriptions were drawn from real-time student operations in each of the courses. The samples included at least seven prescriptions from each of the AIS blocks in the courses. Each of the prescriptions was examined to determine if the dates, times, and student account numbers were correct. For each prescription, the date, time, student account number, and next assignment were then transcribed to report sheets. Next, the block and lesson completion data in the student's SDP, plus the block and lesson hierarchies for the appropriate course and version, were examined to determine if the assigned lesson was enabled (all prerequisites completed). For assignments requiring computer-managed resources, it was determined whether the required resources were in fact immediately available for the student.

### Results

All assignments from all prescriptions in the samples were determined to be both enabled and feasible. The reliability of student prescriptions from the CMI system is 100%.

## Reliability of Resource Allocation

Resource allocation is one of the functions of the AIS CMI system. This function manages all training resources which have been declared in the Course Data Base as computer-managed. The CMI system balances student flow through a course to avoid bottlenecks due to resource unavailability and to maximize usage of critical resources. If a student is assigned to a lesson when in fact resources for that lesson are not available, or if the CMI system determines that a student cannot proceed because of a resource bottleneck when resources are in fact available, then the resource allocation function is not reliable. The lack of reliability would result in inefficient use of student and instructor time. To some extent, this function was tested under "Reliability of

Student Prescriptions," where no failures of the resource allocation function were found. However, a more extensive test was desired.

Procedure

For 30 consecutive calendar days during the IST, instructors in the AIS learning centers gave immediate notice to a test representative of any instance in which one of the following conditions existed: (a) a computer-managed resource for an assigned module was not in fact available for the student's use, or (b) a student's prescription stated that "A resource for your next assignment is not now available" when in fact the resource was available. Instructor notification to the test representatives was in the form of the student prescription annotated by the instructor.

Results

During the 30-day test period, the CMI system issued approximately 6600 assignments involving computer-managed resources (1430 in IM/MF, 2770 in PME, and 2450 in WM). From among these 6600 assignments, only one discrepant prescription was reported by IM/MF instructors; four by PME instructors; and none by the WM instructors. All five discrepancies were of the "student bottlenecked but resources were actually available" nature.

Based on the system performance during this 30-day period, reliability of resource allocation is 99.93% in IM/MF, 99.85% in PME, and 100% in WM.

Following each reported discrepancy, the Course Data Base was checked for errors. None of the discrepancies was determined to have resulted from CMI system error; instead, they were attributable to erroneous maintenance of the data base at the course level (i.e., clerk or instructor).

## V. SUPPORT SYSTEMS TESTING

The Support Systems of the AIS include the central computer with peripherals, terminals, communications, and software and the Related Subsystem which includes facilities, reliability, and maintainability. The Support Systems were tested and analyzed during the IST in the operational training environment of the four prototype AIS courses. The data were accumulated while CMI activities were actually being performed.

During this test period, several of the Support Systems components were not in a stabilized condition:

1. Additional extended core storage (ECS) hardware for the computer was delivered and installation was accomplished during the test.

The installation was accomplished in phases during a 12-week period, and several operational interruptions occurred. Subsequent to the IST, however, the additional ECS has contributed to improved uptime, performance, and reliability.

2. Complete configuration control of the software was not achieved. Many changes and new features were added to the software during the IST.

## System Load Performance

During IST, the AIS system had 50 interactive and 10 management terminals electronically connected to the central computer. The Performance Monitor Program, which analyzes performance data, indicated that a maximum of 19 interactive and 9 management terminals were in operation at any one time. The average student test form transaction rate with this number of terminals was 13.5 forms per minute.

A system load analysis was conducted using data gathered via the Time Sharing Operating System Performance Monitor. This program collected data on central processing unit (CPU) utilization by the various system components. Data relative to each component were then summed and linear extrapolations made for future load. The results showed that the hardware configuration could accommodate 100 interactive terminals and a 1300 student load for CMI, assuming 40% CPU utilization and 65% utilization of interactive terminals including 15% for CMI, 10% for authoring, and 40% for CAI.

## Media System Reliability

During the IST, the media system for the AIS consisted of approximately 440 media devices--filmstrip, slide, and movie projectors, tape playback units, and video playback units and monitors. The instructors in AIS courses completed a media failure tag for each instance of media device failure during a 5 month period. Data from the tags were used to establish the media system mean time between failures (MTBF). The results are shown in Table 16.

TABLE 16. Media System Reliability

| NUMBER OF RELEVANT FAILURES (RESTORATION TIME GREATER THAN 10 MIN.) | SYSTEM OPERATING HOURS | SYSTEM MTBF, HR. | CONTRACT REQUIREMENTS, HR. |
|---|---|---|---|
| 42 | 1303 | 31 | 25 |

Total system operating hours were calculated by multiplying school days by 12 hours per day. A relevant failure is one whose restoration time is greater than 10 minutes. The MTBF was calculated by dividing the total number of relevant failures into the system operating hours.

## Computer Hardware Reliability

Each time an AIS student completes a test form, the student is required to input the data on the form to the central computer via a management terminal. The central computer is located at AFHRL, Lowry AFB, and is connected to the management terminals by a communication system which includes base telephone lines. The student interaction process, which includes the reading of the test form, computer processing and the printout of the prescription at the management terminal, typically takes 40 seconds. Any interruption in this process, due to failures, causes student queues at the terminals and, depending on the length of the interruption, causes alternate procedures to be implemented for the affected course. In either case, interruptions translate to inefficiency.

The purpose of this portion of the IST was to measure periods of availability and to identify the major component failures causing interruptions. The AIS specification required that 90% of all AIS course shifts be operational. Course shifts were, for IST purposes, the standard ATC A and B training school shifts, from 0600 to 1200 hours and from 1200 to 1800 hours. An operational course shift was defined as a course shift that contained none of the following categories of shift failures:

1. Central computer system components inoperable for more than 18 minutes during the shift, excepting failures due to software, external power, water chiller, communication lines, and operator errors, and excepting component failures that still allowed the courses to be operational under CMI.

2. Management terminal inoperative for more than 2 hours.

3. More than one management terminal inoperative in any course for more than 18 minutes.

4. Communication site controller inoperative for more than 2 hours.

An additional goal was to achieve 95% overall system up time, including failures due to hardware, software, personnel, and Government furnished equipment (GFE).

### Procedure

At the central computer site, a log book was maintained by the

computer operator who noted by event and time all major system events. A clerk for each course also noted, in a Problem Report, all events associated with any system interruption. Data were collected from these logs and from certain other computer program reports. A weekly summary report was prepared in which failures, downtime, and system effectiveness data were detailed. These summary reports were presented, discussed, and agreed to at weekly test coordination meetings between representatives of AFHRL/TT, Defense Contract Administration Services Management Area (DCASMA), and MDAC.

## Results

Summary. The 31 weeks of operation during the IST represent a training period of 1800 hours, and 900 course shifts. An overall system up time of 95.6%, including all failure modes, was achieved. Operational status was achieved for 92.2% of the course shifts.

| | |
|---|---|
| Number of weeks of test . . . . . | 31 Weeks |
| Number of school hours tested . . . . . | 1800 hours |
| Number of school hours system operational . . . | 1721 hours (95.6%) |
| Number of course shifts during test . . . . . | 900 shifts |
| Number of course shifts declared operational . | 830 shifts (92.2%) |

Number of system interruptions caused by:

| | |
|---|---|
| Computer Hardware . . . . . | 65 failures |
| Software/Personnel . . . . . | 98 failures |
| Communications . . . . . | 9 failures |

Availability. Of the 65 computer hardware failures, accounting for 72 hours 17 minutes of downtime, 16 caused an operational interruption greater than 18 minutes. Eighteen minutes is 5% of a 6-hour shift and was used as the contractual limit for a shift being judged operational. Six failures accounted for 62 hours of down time. If these six failures were discounted, the total remaining down time for the system caused by the computer components would be 10 hours 17 minutes, with an average of 10 minutes per failure. The computer hardware components accounted for 66 of the 70 shift failures, with ECS problems being the primary factor.

The overall availability of the computer hardware during IST, including periods of system usage beyond the 12-hour daily course periods, was 96.3%. The overall availability through the 3 1/2 years following installation acceptance was 97.3%.

Computer Software. There were 98 software/personnel failures accounting for 12 hours 32 minutes (752 minutes) of down time. Three of these failures exceeded 18 minutes. If they were discounted, the average down time for this type of interruption would be 5 minutes.

Communication Hardware. Nine communication hardware failures accounted for 3 hours 40 minutes. Of these, one caused three shift failures. These were included in the mainframe system components category because the failure was in the communications interface unit (CIU), which has the same effect as a mainframe failure.

Management Terminals. Of the nine management terminals, an average of four terminals a week developed problems. These problems were usually resolved within 20 to 30 minutes, and caused only one shift failure. The printer and reader were the most significant failure items.

## Media Device Maintainability

Log books were provided in classrooms to record on-line equipment maintenance times. Utilizing these log books, plus failure tags and data recorded on the failure reports, the following parameters were determined:

1. Mean and 90% upper limit to repair on-line equipment.
2. Mean and 90% upper limit to remove and replace media equipment.
3. Maintenance hours per operating hour.
4. Mean and 90% upper limit to repair off-line equipment.

Logbooks had to be used exclusively to determine parameter 1. This was the most difficult area for data collection because this kind of maintenance was not reported in sufficient quantity to insure a reliable result. It was estimated that no more than 20% of the failures of this type were reported. Failure to report these data also biased the maintenance manhours per operating hour on the low side since the number of failures and subsequent maintenance times were abnormally small while the system operating time remained the same. Results are shown in Table 17.

Failure tag data were used to determine parameter 2. As mentioned previously, data on these tags were sometimes unreliable and occasionally indicated abnormally long restorations. As shown in Table 17, the restoration goal was not met. It is quite probable, however, that if the failure tag and log book data had been accurate, the goal would have been met.

Parameter 3 was determined by using the total times due to all reported occurrences in parameter 1 and dividing by the total system operating time. Table 17 indicates that the goal for this parameter was met.

Data for determination of parameter 4 were taken from failure reports written for each failure occurrence. Sufficient data were gathered to verify compliance with the goal (Table 17).

TABLE 17. Media Maintainability

| ITEM | TOTAL FAILURE/ MAINTENANCE OCCURRENCES | TOTAL TIME (MIN.) | MEAN | | UPPER 90% POINT | |
|---|---|---|---|---|---|---|
| | | | GOAL | ACTUAL | GOAL | ACTUAL |
| (1) "ON" EQUIPMENT MAINTENANCE TIME | 99 | 938 | 6 Min. | 9.5 Min. | 90% of occurrences less than 13.5 Min. | 85.9% less than 13.5 Min. |
| (2) RESTORATION TIME | 23 | 266 | 10.2 Min. | 11.6 Min. | 90% of occurrences less than 22.8 Min. | 91.3% less than 22.8 Min. |
| (3) MAINT. MAN HOURS PER SYSTEM OPERATING HOUR | 99 Occurrences, 938 Minutes | 91440 | .042 | .010 | N/A | N/A |
| (4) "OFF" EQUIPMENT MAINTENANCE TIME | 222 | 4368 | 42 Min. | 19.8 Min | 90% of occurrences less than 84 Min. | 95.5% less than 84 Min. |

## Reliability of Media Devices

Prior to the IST, instructors in the IM, MF, PME, and WM courses were briefed on the procedures for collecting data required to establish device reliability, maintainability, down time, and system reliability of media devices. The data for device reliability measurements were taken from the failure reports and the Course Evaluation Summary (CES) reports. Operating hours for the media devices were estimated by multiplying the numbers of students taking the mediated modules by the average times on those modules. Failures were categorized by MDAC and agreed upon by AFHRL and DCASMA weekly during the test period. The categories of failures were:

Category I - A failure that requires a part replacement, complete rework of an existing part or an otherwise time consuming effort to repair;

Category II - Such incidents as loose hardware, missing parts, etc., and all adjustments, lubrication, cleaning, etc.;

Category III - Failures caused by humans during operation or maintenance;

Category IV - Those failures for which the cause is unknown; and

Category V - Failures of some easily replaceable items such as light bulbs. However, if a light bulb fails more often than the lifetime prediction or it is difficult to replace, it is placed in Category I.

The total number of Category I failures was then divided into the total hours to yield the MTBF. Data gathered prior to the test period were, in some cases, added to give the final results shown in Table 18.

As indicated in Table 18, all units except the motion picture projector and the filmstrip unit met the reliability goals. It should be noted that some of the measured MTBFs are not reliable due to insufficient hours of utilization. These include video playback units, TV monitors, and slide projectors.

## Media Courseware Reliability

During the IST, instructors in the IM, MF, PME, and WM courses reported incidents of mediated courseware failures to the MDAC Quality Assurance (QA) representative. Usages of mediated modules were available from the Course Evaluation Summary printouts. The numbers of uses for each type were then divided by the numbers of failures to determine the MTBF. Results are shown in Table 19.

TABLE 18. Media Device Reliability

| Device | Total Usage During Test Period, Hr. | MTBF Measured During Test Period, Hr. | Total Hours Usage Including Those Prior to Test Period | Final MTBF | Contract Goals |
|---|---|---|---|---|---|
| 1. Headset | 32,621 | 10,874 | 136,199 | 27,240 | 2,500 |
| 2. Audio Tape Player | 13,223 | 6,612 | 33,394 | 2,783 | 500 |
| 3. Motion Picture Projector | 492 | 98 | 2,364 | 197 | 500 |
| 4. Video Playback | 725 | 363 | 2,315 | 463 | 300 |
| 5. TV Monitor | 725 | 725 | 2,315 | 2,315 | 1,500 |
| 6. Combined Filmstrip and Audio Unit | 18,418 | 302 | 102,509 | 820 | 333* |
| 7. Slide Projector | 930 | ** | 3,711 | 3,711 | 1,500 |
| 8. Microfiche Reader | 12,392 | 2,065 | 30,636 | 2,785 | 1,000 |
| 9. Filmstrip Unit | 12,427 | 377 | 12,427 | 377 | 1,000 |

* Requirement calculated from the combined requirements of the filmstrip and the Audio Tape Units.

** No Category I failures during this period.

TABLE 19. Media Courseware Reliability

| MEDIA COURSEWARE | NUMBER OF USES | NUMBER OF FAILURES | MTBF* | CONTRACT GOALS |
|---|---|---|---|---|
| Super 8 Film | 1548 | 7 | 221 | 150 |
| Video Tape | 962 | 18 | 55 | 50 |
| Filmstrip | 24,445 | 221 | 111 | 250 |
| Audio Tape | 25,154 | 36 | 699 | 500 |

* MTBF in this case means number of uses between failures

As indicated, all goals were met except that for the filmstrip. It appears that the film becomes brittle with use, possibly because of high heat and low humidity. It was recommended that replacement film be treated with a protective coating prior to being placed in the classroom.

## VI. MATERIALS DEVELOPMENT COSTS

The cost of developing instructional materials is an important factor in determining the cost-effectiveness of an educational system. The materials development costs for a computer based training system can vary across an extremely wide range. The actual costs will depend on at least the following factors:

1. Characteristics of the course:

   (A) Categories (e.g., discriminated recall, classification, procedure following, problem solving, and psychomotor), levels, and range (variety) of skills being taught.

   (B) Initial state (clear, well written, up to date, complete) of course documentation (statement of objectives, Plan of Instruction, course charts, etc.).

   (C) Initial state of course materials (manuals, texts, workbooks, audiovisuals, etc.).

(D) Initial state of within-course testing (block tests, performance checks, etc.).

(E) Stability of course content.

(F) Initial configuration of the course (conventional lockstep, self-paced, mediated materials, multitracking, individualization).

(G) Special requirements for the course (team performances, critical resource scheduling, etc.).

(H) Suitability of course content and format to self-pacing and modular presentation.

2. Characteristics of the materials developers:

(A) Familiarity with course content.

(B) Familiarity with the ISD process.

(C) Skill/experience in writing instructional materials and test items.

(D) Skill/experience in developing mediated courseware, multitracking, etc.

(E) Skill/knowledge relating to the computer-based training system being used.

(F) Familiarity with student characteristics and capabilities.

3. Characteristics of the environment:

(A) Organization - Developers part-time or full-time? What other assignments do they have? How are channels between management, developers, and course personnel set up? Part of centralized development team, or local group?

(B) Students - High or low ability? Heterogeneous or homogeneous population? Motivation? Attitude? Critical entry skill levels?

(C) Computer-based system - On-line support for materials development? Support for materials tryouts? Knowledge of programming language required?

(D) Facilities and support - Everything available as needed (terminals, typing, cooperation for materials tryouts, for media development, for CAI and CMI development, for

reviews of materials by subject-matter experts, etc.). Classrooms, carrels, materials and supplies, training devices, etc., all available as needed?

Experience with the AIS courses provides a basis from which to estimate materials development costs. However, the AIS experience cannot be taken as a direct measure of such costs for several reasons. First, the AIS was a prototype development to meet both operational and research needs. Throughout development, costs which were not essential for operational implementation of the courses were nevertheless incurred in order to advance the state-of-the-art in training technology. Second, development of the AIS as a computer-based system proceeded in parallel with the development of instructional materials. Consequently, most of the AIS materials development was accomplished before computer support became available. Third, much of the AIS materials development effort did not begin with stable courses and materials which had been tested in conventional lockstep instruction. Instead, much of the development was for content which had never been taught in the conventional courses and for which the only existing materials were the technical orders (T.O.s) and manufacturers' manuals. Finally, because of the prototype nature of the program and its research aspects, additional steps and organizations, and much additional time, were introduced into the review/revision process. This process should certainly be streamlined for routine development of materials for an operational CBT system.

For the reasons just listed, AIS experience is not an accurate measure of development times and costs which might be incurred in expansion to other courses. Therefore, the following paragraphs present estimates of materials development costs and assume that the AIS experience and "lessons learned" are applied to establish a development process geared solely toward efficient conversion of training courses to AIS computer based training.

## Development Tasks

It is assumed that any course being converted to computer-based instruction has already been the subject of a good tasks analysis, and that the Specialty Training Standard (STS), POI, course chart, block tests, and study materials for the conventional course are all in good order. The subsequent work of conversion to computer-based instruction can be divided into the following task categories:

1. Courseware Development - all work up to implementation in the classrooms, including planning, research, documentation, writing, proofreading, media consultation and review, test preparation, and learning strategies preparation.

2. Implementation - reproduction and collating, planning classroom layout for materials and equipment, providing instruction and assistance to classroom instructors, and entering necessary

information into the CMI course data base.

3. Revision - accomplishing the changes indicated by formative and summative evaluations of the materials.

AIS experience indicates that the manhours required for conversion to computer-based instruction will be divided among these task categories approximately as follows: courseware development, 75%; implementation, 10%; and revision, 15%.*

## Courseware Development Manhours

Estimates of courseware development manhours required for various media are listed in Table 20. These estimates (derived from experience in developing AIS courses) do not include implementation and revision manhours, and assume that the lessons learned during AIS development are applied in converting stable conventionally taught courses to computer-based AIS instruction. The variations in manhours across courses are probably due to the different kinds of content and skills taught in the course (e.g., the IM and MF courses teach principally the clerical skills needed for inventory and issue of supplies and for warehouse operations, the MM course teaches principally the mechanical/motor skills and team performance tasks needed for aircraft preparation, munitions loading, and postflight inspection and repair, and the PME course teaches the cognitive and problem solving skills needed to repair, calibrate, and troubleshoot complex electronic test equipment).

For courseware requiring filmstrips or audio tapes, the media production times indicated in Table 21 should be added to the courseware development times shown in Table 20. In situations requiring individualization (alternate materials presentations designed for subsets of the student population) and assignments according to adaptive decision rules, additional effort from instructional strategies personnel should be applied. The instructional strategies tasks and estimated manhours are as follows:

1. Designing alternative treatments, including data analysis and conceptualization of treatments - 4 hours per candidate lesson.

2. Supporting development of individualized courseware, including coordination with courseware developers and reviewing materials - 12 hours per hour of instruction developed.

3. Deriving and implementing adaptive decision rules, including data analysis - 2 hours per lesson.



* Experience with CAI development for the AIS indicates approximately this same division: 75% development, 10% implementation, and 15% revision.

4. Evaluating the effects of individualization

   (A) Evaluating effects of individualized alternatives and updating decision rules - 15 hours per lesson.

   (B) Evaluating effects of adaptive decision models - 2 hours per lesson.

TABLE 20. Estimated Courseware Development Times, Hours Per POI Hour Developed.

| MEDIUM | COURSE | | |
|---|---|---|---|
| | IM/IF | WI | PME |
| Programmed Text (Main Track) | 60 | 65 | 68 |
| Filmstrip/Audio Tape (Main Track) | 81 | 90 | 98 |
| Filmstrip/Audio Tape (Alternate Track) | 26 | 34 | 38 |
| Video Tape (Main Track) | -- | -- | 98 |
| Motion Picture (Main Track) | -- | -- | 106 |
| Audio Tape (Main Track) | -- | -- | 77 |

TABLE 21. Estimated Media Production Times

| MEDIUM | ESTIMATED HOURS TO PRODUCE A 1-HOUR MASTER |
|---|---|
| Filmstrip | 25 |
| Audio Tape | 4 |

## VII. CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

The IST results from the IM course indicate that superimposing IIA and SPM on an already self-paced CMI course reduced training time by an additional 12.5%. The results from the MF, PME and WM courses indicate that superimposing SPM on already self-paced CMI courses reduced training time by, respectively, 6.7%, 5.1%, and almost 14%.

The reliability and maintainability data collected during IST indicate that the computer-based CMI support functions, the media devices and courseware, and the computer hardware and software are entirely adequate and meet or exceed AIS requirements.

Over and above the specific results obtained during IST, the IST demonstrates that

1. The AIS provides a continuous quality control mechanism for AF technical training.

2. Student attitudes toward AIS computer-based instruction are quite favorable.

3. Maintenance of the media devices, terminals, and communications can be accomplished by AF personnel without extensive AIS-specific training.

4. The AIS operates as an integrated system with extremely flexible capabilities for studying educational innovations.

### Recommendations

The AIS was developed and tested in an operational environment. Prior to and during IST, there was ample opportunity to observe how the system grew, and how it was implemented, utilized, and accepted. These observations lead to the following tentative recommendations.

1. The AIS provides an extremely powerful and unique facility to evaluate the cost-effectiveness of new training and training management technology in a realistic environment. The Air Force should develop procedures and programs to fully utilize this capability in order to exploit the potential for continued improvement in technical training.

2. The SPM functions of the AIS are highly effective in reducing training time in an operational environment, according to the data presented in this report. However, success depends heavily on instructor and training manager attitudes and dedication in monitoring student progress. The effectiveness

of SPH can also be increased by orienting Complementary Technical Training (CTT) and Compulsory and Voluntary Remedial Training (CRT and VRT) around the SPH feedback information. Computer support can enhance management and administrative control of CTT, CRT and VRT.

5. The prototype AIS incorporates sophisticated research capabilities that are not essential to routine support of the majority of ATC technical training. The lessons learned during AIS development should be applied to design a more streamlined and cost-effective system to meet strictly operational training objectives.

4. A computer-based training system, such as the AIS, requires a high degree of organization and coordination among the users. Lines of authority and communication must be clearly established and observed. Configuration control over classroom materials and procedures and over system characteristics is essential to operation and evaluation of or by the system. Advance coordination of changes is vital to smooth operation of the system.

3. Full understanding and utilization of the capabilities provided by a computer-based training system require effort and time from training personnel. The Course Evaluation Summary and the Test Item Evaluation Summary are computer-generated reports that are extremely useful in evaluating course materials and student performance on a continuing basis. Training for high, middle, and working level management is required if computer capabilities are to be fully exploited.

6. The introduction of advanced technology increases the sophistication of courseware development. Utilization of instructors in the 6 + 2 environment* and frequent turnover of personnel further complicate the problem. A simplified, prescriptive method of courseware management and development needs to be developed.

7. Courses to be implemented as AIS courses should be selected carefully. At the present time, the investment necessary to convert a course to computer-based operation should be made only if student flow is high enough and course content is stable enough that the investment can be recovered through reductions in training time. New techniques for converting short, low-flow courses should be investigated.



* An ATC instructor spends 6 hours a day in the classroom and 2 hours a day on outside-the-classroom preparation and administrative duties.

8. Three approaches to IIA have been implemented in the AIS. The regression model approach has considerable promise but is difficult to maintain in the operational mode. The heuristic approach (logical assignment rules) and the learner choice approach promise more utility for the operational environment.

9. Qualified instructors are essential to some of the AIS learning center tasks, but other tasks should be assumed by less highly qualified personnel. Even if total manpower spaces are not reduced, a change in the mix of instructors would result in considerable cost savings.

10. The maintenance of the terminals and associated communications is straightforward. For example, two-shift operations during IST were supported with the equivalent of four full time maintenance technicians. These technicians were either retired AF enlisted personnel or active duty "moonlighting" enlisted personnel. Because of the simplicity of the equipment, vendor manuals and austere documentation were utilized and were considered completely adequate.

# APPENDIX A

## LIST OF PREASSESSMENT TESTS

PREASSESSMENT TESTS USED IN THE IM AND MF COURSES

| | |
|---|---|
| Logical Reasoning Test | Measures general ability to judge the logical soundness of meaningful conclusions by reasoning from stated premises under timed conditions. |
| IM/MF Reading Skills Scale | Measures reading comprehension and speed on materials extracted from IM and MF technical manuals. |
| Concealed Figures Test | Measures ability under timed conditions to make perceptual distinctions by deciding which of five geometrical figures is embedded in a complex pattern. |
| Memory For Numbers Test | Measures ability to remember numbers from 3 to 7 digits in length, with forward and backward digit span subscales. |
| Attitude Toward Course Materials | Measures how tense or apprehensive versus interested or motivated a student feels about learning the IM or MF materials. |
| General Attitude Scale | Measures general tendency to experience feelings of tension and apprehension in situations perceived as threatening versus feelings of interest in a variety of technical areas. |
| Internal-External Scale | Measures tendency to feel in control of events versus feelings of being controlled by external events. |
| Test Taking Attitude Scale | Measures tendency to feel anxious when taking performance or achievement tests. |
| Delta Biographical Data | A variety of biographical and background information items felt to be important for success or failure in the IM and MF courses. |
| General Media Preference Scale | Measures preferences for visual vs. audio vs. printed materials, as well as experience with conventional and self paced instructional methods. |

PREASSESSMENT TESTS USED IN THE PME COURSE

| | |
|---|---|
| Ship Destination Test | Measures general arithmetic or problem solving ability, using specific rules to solve problems under timed conditions. |
| PME Reading Skills Scale | Measures reading comprehension and speed on materials extracted from PME technical orders and manuals. |
| Reading Vocabulary Test | Measures comprehension, under timed conditions, of terms frequently used in Air Force documents and manuals. |
| Hidden Figures Test | Measures ability, under timed conditions, to make perceptual distinctions by deciding which of five geometrical figures is embedded in a complex pattern. |
| Attitude Toward Course Materials | Measures how tense or apprehensive versus interested or motivated a student feels about learning the PME course materials. |
| General Attitude Scale | Measures general tendency to experience feelings of tension and apprehension in situations perceived as threatening versus feelings of interest in a variety of technical areas. |
| Internal-External Scale | Measures tendency to feel in control of events versus controlled by external events. |
| Test Taking Attitude Scale | Measures tendency to feel anxious when taking performance or achievement tests. |
| Delta Biographical Data | A variety of biographical and background information items felt to be important for success or failure in the PME course. |
| General Media Preference Scale | Measures preferences for visual vs. audio vs. printed materials, as well as experience with conventional and self-paced instructional methods. |

PREASSESSMENT TESTS USED IN THE WM COURSE

| | |
|---|---|
| Choosing a Path Test | Measures ability to manipulate ideas visually, under timed conditions, which is considered to be an important ability for many types of work with mechanical devices. |
| WM Reading Skills Scale | Measures reading comprehension and speed on materials extracted from WM technical orders and manuals. |
| Reading Vocabulary Test | Measures comprehension, under timed conditions, of terms frequently used in Air Force documents and manuals. |
| Concealed Figures Test | Measures ability, under timed conditions, to make perceptual distinctions by deciding which of five geometrical figures is embedded in a complex pattern. |
| Associative Memory Test | Measures ability, under timed conditions, to recognize correct associations or concepts for alphanumeric codes frequently used in WM technical manuals. |
| Ship Destination Test | Measures general arithmetic or problem solving ability, using specific rules to solve problems under timed conditions. |
| Attitude Toward Course Materials | Measures how tense or apprehensive versus motivated or interested a student feels about learning the WM course materials. |
| Mechanical Curiosity Scale | Measures general feelings of interest in, or tendency to become interested in, mechanical devices and mechanical problems. |
| Internal-External Scale | Measures tendency to feel in control of events versus controlled by external events. |
| Test Taking Attitude Scale | Measures tendency to become anxious when taking performance or achievement tests. |

PREASSESSMENT TESTS USED IN THE WM COURSE (Concluded)

| | |
|---|---|
| Delta Biographical Data | A variety of biographical and background information items felt to be important for success or failure in the WM course. |
| General Media Preference Scale | Measures preferences for visual vs. audio vs. printed materials, as well as experience with conventional and self paced instructional methods. |
| Math Familiarization Test | Measures basic mathematical skills, under timed conditions, on easy and difficult subscales, with problems that are required in certain areas of the WM course. |

# APPENDIX B

## EXAMPLES OF AIS COMPUTER-GENERATED PRINTOUTS

LEARNING CENTER NEW ROSTER  DAY 9057  1025 HRS

LEARNING CENTER 101  SHIFT 1

| GT# | | ABS | SAN | NAME | PK | DAYS REM | DAYS AHEAD |
|---|---|---|---|---|---|---|---|
| 1 | C | | [redacted] | [redacted] | 2 | 2.8 | -5.2 |
| 2 | C | | [redacted] | [redacted] | 6 | -5.2 | -7.6* |
| 3 | C | | [redacted] | [redacted] | 3 | 6.6 | -2.6 |
| 4 | C | A Ø | [redacted] | [redacted] | 5 | 1.6 | -5.8 |
| 5 | C | | [redacted] | [redacted] | 2 | 12.2 | Ø.2 |
| 6 | C | | [redacted] | [redacted] | 6 | Ø.4 | -2.6 |
| 7 | C | | [redacted] | [redacted] | 2 | 8.8 | Ø.8 |
| 8 | C | | [redacted] | [redacted] | 3 | 2.4 | -5.2 |
| 10 | C | | [redacted] | [redacted] | 2 | 12.8 | 1.6 |
| 11 | C | | [redacted] | [redacted] | 3 | 4.8 | -3.2 |
| 12 | C | | [redacted] | [redacted] | 1 | 16.8 | Ø.2 |
| 13 | C | | [redacted] | [redacted] | 3 | Ø.8 | -10.Ø* |
| 14 | C | | [redacted] | [redacted] | 1 | 15.2 | 2.Ø* |
| 15 | C | | [redacted] | [redacted] | 3 | 6.6 | -2.2 |
| 16 | C | | [redacted] | [redacted] | 3 | 6.2 | -3.2 |
| 17 | C | | [redacted] | [redacted] | 5 | 3.8 | -7.6 |
| 19 | C | | [redacted] | [redacted] | 3 | 6.Ø | 2.4 |
| 20 | C | | [redacted] | [redacted] | 2 | 13.6 | Ø.8 |
| 21 | C | | [redacted] | [redacted] | 3 | 2.2 | -6.4 |
| 22 | C | | [redacted] | [redacted] | 3 | 8.2 | Ø.8 |
| 23 | C | | [redacted] | [redacted] | 3 | 4.Ø | -2.8 |
| 24 | C | A Ø | [redacted] | [redacted] | 3 | 8.4 | -Ø.4 |
| 25 | C | | [redacted] | [redacted] | 6 | 8.4 | 6.4 |
| 26 | C | | [redacted] | [redacted] | 2 | 5.2 | -6.8* |
| 27 | C | | [redacted] | [redacted] | 3 | 10.Ø | 1.Ø |
| 28 | C | | [redacted] | [redacted] | 3 | 6.8 | -2.8 |
| 29 | C | | [redacted] | [redacted] | 5 | 8.2 | 2.2 |
| 30 | C | A Ø | [redacted] | [redacted] | 4 | 7.Ø | Ø.Ø |
| 31 | C | | [redacted] | [redacted] | 3 | 9.Ø | 1.2 |
| 32 | C | | [redacted] | [redacted] | 2 | 8.4 | -Ø.2 |
| 33 | C | | [redacted] | [redacted] | 5 | 2.4 | -1.8 |
| 34 | C | | [redacted] | [redacted] | 2 | 3.4 | -1.2 |

Learning Center Roster. For each student, the following information is listed: assigned carrel or work station number (the following "C" indicates these are carrels); an "A" in the ABS column if a student is absent, followed by a Ø if the absence is less than 1 day; social security number; name; current block of instruction; days remaining until the student's predicted graduation date; and number of days student is ahead of (or, if -, behind) predicted schedule.

GRADUATION ROSTER DAY 9092 1507 HRS

LEARNING CENTER 102 SHIFT 1

| SSN | STUDENT NAME | GRADUATION DATE |
|---|---|---|
| | | MON APR 2, 1979 |
| | | TUE APR 3, 1979 |
| | | TUE APR 3, 1979 |
| | | WED APR 4, 1979 |
| | | WED APR 4, 1979 |
| | | THR APR 5, 1979 |
| | | THR APR 5, 1979 |
| | | FRI APR 6, 1979 |
| | | FRI APR 6, 1979 |
| | | FRI APR 6, 1979 |
| | | MON APR 9, 1979 |
| | | WED APR 11, 1979 |
| | | THR APR 12, 1979 |
| | | FRI APR 13, 1979 |
| | | MON APR 16, 1979 |

Graduation Roster. Lists the students who are targeted to graduate from the current date forward to a date specified by the requester. Available to instructors on request.

ASSIGNMENT STATUS ROSTER DAY 9057 1027 HRS

LEARNING CENTER 101 SHIFT 1

| SAN | NAME | ASSIGNMENT STATUS |
|---|---|---|
| | | LSN 02 09 MOD 01 TEST 03 |
| | | LSN 06 04 MOD 01 TEST 02 |
| | | IN BLOCK REMEDIATION |
| | | LSN 05 08 MOD 01 TEST 01 |
| | | LSN 02-07 MOD 01 TEST 02 |
| | | LSN 06 03 MOD 01 TEST 01 |
| | | LSN 02 08 MOD 01 TEST 04 |
| | | IN BLOCK REMEDIATION |
| | | LSN 02-02 MOD 01 TEST 04 |
| | | LSN 03-09 MOD 01 |
| | | LSN 01 03 MOD 01 TEST 04 |
| | | LSN 03-03 MOD 01 TEST 01 |
| | | LSN 01 04 MOD 01 TEST 03 |
| | | LSN 03-01 MOD 01 TEST 02 |
| | | LSN 03-04 MOD 01 TEST 01 |
| | | LSN 05 05 MOD 01 TEST 01 |
| | | LSN 03-07 MOD 01 TEST 03 |
| | | LSN 02-10 MOD 01 |
| | | LSN 03 03 MOD 01 TEST 02 |
| | | LSN 03-09 MOD 01 |
| | | LSN 03-09 MOD 01 |
| | | LSN 03-03 MOD 01 TEST 01 |
| | | LSN 06-04 MOD 01 TEST 02 |
| | | IN BLOCK REMEDIATION |
| | | LSN 03-03 MOD 01 TEST 01 |
| | | LSN 03-01 MOD 01 TEST 02 |
| | | LSN 05-02 MOD 01 TEST 02 |
| | | LSN 04-02 MOD 01 TEST 04 |
| | | LSN 03 06 MOD 01 TEST 01 |
| | | IN BLOCK REMEDIATION |
| | | LSN 05-06 MOD 01 TEST 01 |
| | | LSN 02-05 MOD 55 |

Assignment Status Roster. Lists the students in a learning center, and shows the current assignment of each student (lesson, module, and test, or other assignment). Available to instructors on request.

LEARNING CENTER RESOURCES  DAY 9057  1027 HRS

LEARNING CENTER 101  SHIFT 1

| GT# | SAN | NAME | TYPE | POOL |
|---|---|---|---|---|
| 7 C | | | P 0003 | 1 01 |

Resource Assignment Roster. Lists the students currently using computer-managed resources, with the following information: carrel number, social security number, student's name; the device - portable (P) or facility (F), and type number (0003 is a microfiche reader); and the location (pool) from which the resource was drawn.

MEMORIZATION SKILLS
DEFICIENCY SCORE 16

day 0058, 1325 hrs

Learning Center 5  Shift 1

INVENTORY MANAGEMENT.

Test # 0043037
Completed at 1325 hrs, day 0058

YOUR NEXT ASSIGNMENT IS: Test #0001007.
Please see your instructor for the necessary test materials

Preassessment Testing Feedback. Indicates, to instructors, the students who have deficiency (or proficiency) scores on any of the tests.

day 9075, 1318 hrs

'Home Carrel 5, Learning Center 2, Shift 1
INVENTORY MANAGEMENT(VERSION 7).

Date Course Started 79/03/15
Date Arrived On Base 79/03/14
Date Of Birth 55/06/028
Sex Male
Highest Year Attended 12
Highest Diploma or Degree High School Graduate
National Status U. S. Military
Military Rank U. S. Military
Military Grade 1
Military Squadron 3441
Military Type of Student Nonprior Service Enlistee
Military Service Branch Air Force
Military Unit Regular
Military Status Active

Registration Feedback. Lists the information read from a student's registration form, for verification.

Targeted days in course 16

Targeted graduation date is TUE MAR 20, 1979

Targeted days per block:

| Block | Days |
|---|---|
| 1 | 2.2 |
| 2 | 3.6 |
| 3 | 3.0 |
| 4 | 1.8 |
| 5 | 2.6 |
| 6 | 2.4 |

day 9058, 1326 hrs

INVENTORY MANAGEMENT.

Test # 0002007
Completed at 1326 hrs, day 9058

YOUR NEXT ASSIGNMENT IS: Lesson 00-10, Module #01, Attempt #1.
"TIME MANAGEMENT" Mastery Test #1

GOOD WORK //

Student's First Assignment in Course. Gives targeted days in course and in each block, targeted graduation date, and student's first assignment to course materials.

day 0957, 0959 hrs

INVENTORY MANAGEMENT.

Days of course completed 9.6
Days spent in class 12.4

Lesson 04 04, Mod #01, Test #3, 315 minutes on Attempt #1.

CONGRATULATIONS. Mastery Test Score 100%..

**********

YOUR NEXT ASSIGNMENT IS: Lesson 04 05, Module #01, Attempt #1.
"CHIEF OF SUPPLY LABORATORY"

GOOD WORK */

Student's First Assignment of Each Class Day. Provides student with progress management information, results on just-completed lesson, and next assignment.

day 9057, 1007 hrs

INVENTORY MANAGEMENT.

Lesson 1 Completed on Attempt 1
Lesson 2 Completed on Attempt 1
Lesson 3 Completed on Attempt 1
Lesson 4 Completed on Attempt 1

Student's Completion Status for Current Block. Lists lessons completed and numbers of attempts. Available to instructors on request.

```
                                                    day 9057, 1228 hrs

   IM A AND B SHIFT 6-HOUR STUDENTS.

   Days of course completed  23.8
   Days spent in class  17.0


Block 1 Completed on Attempt 1
Block 2 Completed on Attempt 1
Block 3 Completed on Attempt 1
Block 4 Completed on Attempt 1
Block 5 Completed on Attempt 1
status for block 6
  Lesson 1 Completed on Attempt 1
  Lesson 2 Completed on Attempt 2
```

Student's Completion Status for the Course. Summarizes progress management information (days of course completed vs. days in class), the blocks completed and numbers of attempts, and, for current block, the lessons completed and numbers of attempts. Available to instructors on request.

STUDENTS SAMPLED: 181

GRADUATES: 166 ACADEMIC ELIMINEES: 6 NON-ACADEMIC ELIMINEES: 9

ALL CALCULATIONS CONSIDER ABSENCE TIME EXCLUDED

| | | | | | |
|---|---|---|---|---|---|
| MEAN TIME(MIN) TO ELIMINATION : | 6174.15 | SD | 3937.39 | N | 13 |
| MEAN TIME(MIN) TO GRADUATE : | 13371.88 | SD | 4030.18 | N | 123 |
| MEAN TIME(DAY) TO GRADUATE : | 39.03 | SD | 12.04 | N | 123 |
| MEAN TIME(MIN) PER STUDENT : | 12663.86 | SD | 4535.23 | N | 136 |

ACROSS BLOCK TIMES AND SCORES; ALL TIME IN MINUTES

| BLOCK | MEAN TIME | SD TIME | N | MEAN SCORE | SD SCORE | N |
|---|---|---|---|---|---|---|
| 1 | 6080.279 | 1996.085 | 68 | 84.906 | 9.386 | 106 |
| 2 | 4371.028 | 1720.041 | 108 | 77.507 | 14.320 | 67 |
| 3 | 657.500 | 154.360 | 4 | 85.750 | 14.500 | 4 |
| 4 | 404.250 | 126.186 | 4 | 93.500 | 7.506 | 4 |
| 5 | 1591.333 | 508.524 | 3 | 77.000 | 10.231 | 4 |
| 6 | 1509.750 | 425.449 | 4 | 90.250 | 6.551 | 4 |
| 7 | 520.667 | 185.635 | 3 | 85.000 | 14.142 | 2 |
| 8 | 2883.000 | 0 | 1 | 86.000 | 5.657 | 2 |
| 9 | 1035.000 | 565.685 | 2 | 81.500 | 12.021 | 2 |
| 10 | 1169.000 | 401.637 | 2 | 88.000 | 7.071 | 2 |
| 11 | 1449.000 | 677.408 | 2 | 80.000 | 4.243 | 2 |
| 12 | 952.000 | 253.144 | 2 | 77.000 | 11.314 | 2 |
| 13 | 1062.500 | 231.224 | 2 | 84.000 | 11.314 | 2 |
| 14 | 689.750 | 205.894 | 4 | 0 | 0 | 0 |



Course Evaluation Summary (CES). Summary page of the CES report, showing mean times in the course and mean times, mean scores, and standard deviations for each of the blocks in the course.

LESSON SUMMARY COURSE 4, VERSION ANY, BLOCK 1, LESSON 92.

| MODULE NO.-SAMPLE SIZE: | | 1 | - N | 2 | - N | ALL MODLS ALL | - N |
|---|---|---|---|---|---|---|---|
| 1ST ATTEMPT | - TOTAL FAIL RATE | 12 | 26 | 11 | 9 | 11 | 35 |
| | - PCT COG FAILURES | 12 | 26 | 11 | 9 | 11 | 35 |
| | - PCT PERF FAILURE | 4 | 26 | 0 | 9 | 3 | 35 |
| | - COGN SCORE MEAN | 89 | 23 | 91 | 9 | 89 | 32 |
| | - COGN SCORE SD DV | 8 | 23 | 12 | 9 | 9 | 32 |
| | - TIME(MIN) MEAN | 130 | 9 | 209 | 1 | 138 | 10 |
| | - TIME(MIN) SD DEV | 92 | 9 | 0 | 1 | 91 | 10 |
| | - PCT STU TAKING | 74 | 26 | 26 | 9 | 100 | 35 |
| CORR ACTUAL SCORE TO PREDICTED | | | | | | 0 | 0 |
| -STANDARD ERROR ESTIMATE | | | | | | 0 | 0 |
| CORR ACTUAL TIME TO PREDICTED | | | | | | 0 | 0 |
| -STANDARD ERROR ESTIMATE | | | | | | 0 | 0 |
| TOTAL TIME TO MASTERY | - MEAN | 263 | 22 | 308 | 9 | 276 | 31 |
| | - STD DEV | 153 | 22 | 73 | 9 | 135 | 31 |
| PCT 1ST ATT FAIL RATE | - OBJ 1 | 12 | 26 | 0 | 9 | 9 | 35 |
| | - OBJ 2 | 12 | 26 | 11 | 9 | 11 | 35 |

CES (continued). Example page showing performance statistics for all of the modules (alternative presentations) of one lesson in the course.

COURSE- 3 COURSE VERSION- 1 TEST TYPE-BLOCK COGNITIVE TEST

BLOCK- 7 TEST NO- 1 ( 7 103)
REVISION NO- 2 EFFECTIVITY 78205 TO 99365 CURRENT
SELECTION CRITERIA USED- NONE

TEST SUMMARY SAMPLE DATE RANGE- 78205 TO 79064

NO. RECORDS EXAMINED- 115 NO. SAMPLES- 115(100 PCT)

NO. TEST FAILURES- 24( 21.PCT)
NO. FAIL DUE TO TOTAL PCT- 24( 20 PCT CRITERION- 70 PCT
NO. FAIL DUE TO NO.OBJ.FAIL-. 0( PCT) CRITERION- 0 OBJ
NO. FAIL DUE TO CRIT OBJ FAIL- 0( 0.PCT)

SCALE SUMMARY - PART 1

| SCALE | ID/ OBJ. | NO. SAMPLES/ FAILURES/PCT | | | NO. ITEMS | MEAN SCORE | STAND DEVTN | CRITCL OBJ | PASSING/ MAXIMUM | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7- 0- 1 | 115/ | 84/ | 73. | 6 | 4.70 | 1.100 | NO | 6/ | 6 |
| 2 | 7- 0- 2 | 115/ | 92/ | 80. | 4 | 2.78 | .896 | NO | 4/ | 4 |
| 3 | 7- 0- 3 | 115/ | 93/ | 81. | 6 | 4.49 | 1.180 | NO | 6/ | 6 |
| 4 | 7- 0- 4 | 115/ | 58/ | 50. | 3 | 2.30 | .827 | NO | 3/ | 3 |
| 5 | 7- 0- 5 | 115/ | 71/ | 62. | 4 | 2.97 | 1.047 | NO | 4/ | 4 |
| 6 | 7- 0- 6 | 115/ | 94/ | 82. | 4 | 2.53 | 1.103 | NO | 4/ | 4 |
| 7 | 7- 0- 7 | 115/ | 83/ | 72. | 3 | 2.10 | .701 | NO | 3/ | 3 |
| TOTAL | N/A | 115/ | 24/ | 21. | 30 | 72.90 | 13.591 | N/A | 70/100 | |

SCALE SUMMARY - PART 2

| SCALE | SKEW* | KURTOSIS* | REMAIN.CORR P(TOTAL) | ALPHA RELIAB. | LIVING. COEFF. |
|---|---|---|---|---|---|
| 1 | -2.917 | .149 | .2638 | .3368 | .8402 |
| 2 | -2.256 | -.857 | .3262 | .3064 | .9744 |
| 3 | -3.877 | 2.419 | .4994 | .3706 | .8880 |
| 4 | -4.237 | .381 | .4474 | .4341 | .8845 |
| 5 | -3.605 | -.297 | .5532 | .4564 | .8880 |
| 6 | -2.841 | -.210 | .4489 | .3399 | .9774 |
| 7 | -1.925 | .227 | .2152 | .1632 | 1.0014 |
| TOTAL | -5.125 | 3.748 | N/A | .7232 | .7369 |

*SKEW GT 0 = SKEWED TO RIGHT
EQ 0 = NORMAL
LT 0 = SKEWED TO LEFT
*KURTOSIS GT 0 = PEAKED
EQ 0 = NORMAL
LT 0 = FLAT

Test Item Evaluation (TIE) Report.

ITEM STATISTICS BY SCALE

| ITEM | SCALE | MEAN/MAX SCORE | STD DEV | FAILURES NO. (PCT) | ITEM-REMAIN. R(TOTAL) | CORR. R(SCALE) | CRIT ITEMS |
|---|---|---|---|---|---|---|---|
| 1 | 1 | .53/ 1. | .501 | 54(47.) | .2651 | .2997 | NO |
| 2 | 1 | .89/ 1. | .318 | 13(11.) | .0598 | .0703 | NO |
| 3 | 1 | .92/ 1. | .270 | 9( 8.) | .3563 | .1601 | NO |
| 4 | 1 | .76/ 1. | .431 | 28(24.) | .2271 | .2341 | NO |
| 5 | 1 | .63/ 1. | .484 | 42(37.) | -.0051 | .1570 | NO |
| 6 | 2 | .86/ 1. | .348 | 16(14.) | .1392 | .3035 | NO |
| 7 | 2 | .67/ 1. | .472 | 38(33.) | .2726 | .2337 | NO |
| 8 | 2 | .31/ 1. | .466 | 79(69.) | .1657 | .0532 | NO |
| 9 | 2 | .94/ 1. | .240 | 7( 6.) | .2691 | .0824 | NO |
| 10 | 3 | .76/ 1. | .431 | 28(24.) | .1695 | .2103 | NO |
| 11 | 3 | .90/ 1. | .307 | 12(10.) | .3513 | .1324 | NO |
| 12 | 3 | .91/ 1. | .283 | 10( 9.) | .2922 | .1912 | NO |
| 13 | 3 | .75/ 1. | .436 | 29(25.) | .1900 | .2298 | NO |
| 14 | 3 | .78/ 1. | .414 | 25(22.) | .4377 | .1983 | NO |
| 15 | 3 | .39/ 1. | .490 | 70(61.) | .1691 | .0994 | NO |
| 16 | 5 | .78/ 1. | .414 | 25(22.) | .2858 | .1857 | NO |
| 17 | 5 | .72/ 1. | .450 | 32(28.) | .3904 | .2849 | NO |
| 18 | 5 | .89/ 1. | .318 | 13(11.) | .5141 | .3091 | NO |
| 19 | 4 | .83/ 1. | .381 | 20(17.) | .2849 | .2254 | NO |
| 20 | 4 | .90/ 1. | .307 | 12(10.) | .3291 | .3312 | NO |
| 21 | 4 | .57/ 1. | .497 | 49(43.) | .3723 | .2742 | NO |
| 22 | 6 | .72/ 1. | .450 | 32(28.) | .1652 | .1641 | NO |
| 23 | 6 | .64/ 1. | .481 | 41(36.) | .3781 | .2109 | NO |
| 24 | 6 | .49/ 1. | .502 | 59(51.) | .1837 | .1145 | NO |
| 25 | 6 | .68/ 1. | .469 | 37(32.) | .3614 | .2420 | NO |
| 26 | 7 | .96/ 1. | .205 | 5( 4.) | .0587 | .1122 | NO |
| 27 | 5 | .58/ 1. | .495 | 48(42.) | .2891 | .2861 | NO |
| 28 | 1 | .97/ 1. | .168 | 3( 3.) | .0632 | -.0899 | NO |
| 29 | 7 | .79/ 1. | .408 | 24(21.) | .0580 | .0930 | NO |
| 30 | 7 | .35/ 1. | .478 | 75(65.) | .2622 | .0806 | NO |

Test Item Evaluation (TIE) Report (continued).

ITEM CHOICE DISTRIBUTIONS

NO. SAMPLES 115.

| ITEM | RAW SCORES A | B | C | D | E | MISS/ MULT | CHOICE HAVING MAX SCORE | MEAN NO. MARKS | PERCENT SCORES A | B | C | D | E |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 19 | 8 | 4 | 23 | 67 | 0/ | 6 E | 1.052 | 17. | 7. | 3. | 20. | 58. |
| 2 | 103 | 5 | 8 | 0 | 0 | 0/ | 1 A | 1.009 | 90. | 4. | 7. | 0. | 0. |
| 3 | 2 | 107 | 3 | 3 | 0 | 1/ | 1 B | 1.000 | 2. | 93. | 3. | 3. | 0. |
| 4 | 0 | 4 | 14 | 10 | 89 | 0/ | 2 E | 1.017 | 0. | 3. | 12. | 9. | 77. |
| 5 | 0 | 41 | 75 | 0 | 0 | 1/ | 2 C | 1.009 | 0. | 36. | 65. | 0. | 0. |
| 6 | 9 | 4 | 1 | 100 | 0 | 2/ | 1 D | .991 | 8. | 3. | 1. | 87. | 0. |
| 7 | 15 | 6 | 1 | 80 | 15 | 2/ | 4 D | 1.017 | 13. | 5. | 1. | 70. | 13. |
| 8 | 32 | 39 | 3 | 2 | 42 | 1/ | 4 B | 1.026 | 28. | 34. | 3. | 2. | 37. |
| 9 | 2 | 108 | 0 | 1 | 1 | 3/ | 0 B | .974 | 2. | 94. | 0. | 1. | 1. |
| 10 | 1 | 0 | 88 | 11 | 14 | 2/ | 1 C | .991 | 1. | 0. | 77. | 10. | 12. |
| 11 | 4 | 2 | 4 | 103 | 0 | 2/ | 0 D | .983 | 3. | 2. | 3. | 90. | 0. |
| 12 | 3 | 106 | 1 | 2 | 2 | 2/ | 1 B | .991 | 3. | 92. | 1. | 2. | 2. |
| 13 | 6 | 1 | 18 | 1 | 88 | 3/ | 2 E | .991 | 5. | 1. | 16. | 1. | 77. |
| 14 | 90 | 22 | 1 | 0 | 0 | 2/ | 0 A | .983 | 78. | 19. | 1. | 0. | 0. |
| 15 | 6 | 58 | 55 | 4 | 0 | 2/ | 10 C | 1.070 | 5. | 50. | 48. | 3. | 0. |
| 16 | 91 | 1 | 8 | 9 | 3 | 4/ | 1 A | .974 | 79. | 1. | 7. | 8. | 3. |
| 17 | 0 | 6 | 22 | 4 | 85 | 2/ | 4 E | 1.017 | 0. | 5. | 19. | 3. | 74. |
| 18 | 103 | 5 | 3 | 1 | 1 | 4/ | 2 A | .983 | 90. | 4. | 3. | 1. | 1. |
| 19 | 95 | 1 | 8 | 4 | 2 | 5/ | 0 A | .957 | 83. | 1. | 7. | 3. | 2. |
| 20 | 3 | 4 | 104 | 2 | 1 | 2/ | 1 C | .991 | 3. | 3. | 90. | 2. | 1. |
| 21 | 0 | 11 | 10 | 16 | 67 | 5/ | 2 E | .974 | 7. | 10. | 9. | 14. | 58. |
| 22 | 8 | 8 | 11 | 87 | 2 | 3/ | 4 D | 1.009 | 7. | 7. | 10. | 76. | 2. |
| 23 | 8 | 76 | 9 | 3 | 16 | 5/ | 2 B | .974 | 7. | 66. | 8. | 3. | 14. |
| 24 | 4 | 18 | 25 | 58 | 7 | 5/ | 2 D | .974 | 3. | 16. | 22. | 50. | 6. |
| 25 | 1 | 5 | 13 | 12 | 80 | 1/ | 2 E | 1.009 | 1. | 4. | 16. | 10. | 70. |
| 26 | 2 | 110 | 1 | 2 | 0 | 0/ | 0 B | 1.000 | 2. | 96. | 1. | 2. | 0. |
| 27 | 8 | 68 | 29 | 11 | 0 | 0/ | 1 B | 1.009 | 7. | 59. | 25. | 10. | 0. |
| 28 | 0 | 1 | 1 | 112 | 1 | 0/ | 0 D | 1.000 | 0. | 1. | 1. | 97. | 1. |
| 29 | 0 | 5 | 15 | 92 | 2 | 2/ | 1 D | .991 | 0. | 4. | 13. | 80. | 2. |
| 30 | 11 | 44 | 32 | 17 | 13 | 2/ | 4 B | 1.017 | 10. | 38. | 28. | 15. | 11. |



Test Item Evaluation Report (concluded)

# APPENDIX C

## STUDENT ATTITUDE DATA

## STUDENT ATTITUDE DATA

Each student in the AIS courses during IST completed a 40-item attitude questionnaire at the end of the first AIS block of instruction, and again at the end of the course. This questionnaire (Figure C-1) measured students' attitudes toward various features of the AIS courses. Item responses were "strongly agree," "agree," "neutral," "disagree," and "strongly disagree." As presented to the students, a "strongly agree" response on 15 items indicated a favorable attitude toward AIS in areas such as self-pacing, amount of testing, mediated instruction, and availability of instructors. The remaining 25 items were worded such that a "strongly disagree" response reflected a favorable attitude.

A summary of the item data from end-of-course administrations of the attitude questionnaire is shown in Table C-1. The abbreviated item statements in this table are all worded so that agreement with the statement indicates a favorable attitude toward the course. As presented to the students, however, items 3, 7 to 11, 16 to 22, and 28 to 39 were worded to require a "disagree" or "strongly disagree" response if the student actually felt favorable toward the course. In Table C-1, the percentages of favorable responses ("agree" and "strongly agree" on 15 items, and "disagree" and "strongly disagree" on 25 items) are tabulated as positive, the percentages of unfavorable responses are tabulated as negative, and the percentages of "neutral" responses appear as neutral.

Overall, students who have completed the AIS courses report favorably on the individualized self-paced CMI aspects, and indicate that in general they did feel motivated to work, and did not feel the courses were boring nor that the courses were depersonalized.

Table C-2 summarizes the attitude questionnaire results from the AIS courses during IST. For this summary, responses were scored on a 1-5 scale, with 1 being the most unfavorable response to an item and 5 being the most favorable. A single attitude score was derived for each student in the samples by averaging response values for the 40 items. The mean attitude scores for the groups in Table C-2 range from 3.98 (IM course, Phase II Main Track, end of Block I) to 3.53 (WM course, Phase II, end of course), and all are toward the favorable end of the scale.

## STUDENT ATTITUDE QUESTIONNAIRE

DIRECTIONS: The following statements apply to the way you felt about the various aspects of this AIS course. Do not hesitate to describe exactly how you felt. It will help us improve the training program. Read each statement carefully and then blacken the appropriate space on your answer sheet to indicate how you felt about this AIS course.

Mark "A" on your answer sheet if you strongly disagree with the statement, "B" if you disagree, "C" if you are neutral about the statement, "D" if you agree, and "E" if you strongly agree with the statement.

There are no right or wrong answers. Do not spend too much time on any one statement, but choose the answer which best describes how you felt.

1. I felt I could work at my own pace.

2. I was satisfied with what I learned in this course.

3. Under self-pacing, I had less opportunity to talk individually to the instructor than in conventional courses I have had.

4. My feeling toward the course materials was favorable.

5. I am anxious to get to my first assignment after finishing tech school.

6. I expect my Air Force technical training will help me get a good civilian job later.

7. Since Denver is such a nice area, I was not in any hurry to finish the course.

8. I had to fill out too many forms in this course.

9. I would have liked more opportunity to work in a group.

10. This self-paced instruction was a poor use of my time.

11. I saw no reason to hurry through the course.

12. Compared to lectures, this self-paced course was a better way for me to learn.

13. I would prefer my future AF courses to be this type of instruction rather than lectures.

14. I liked being informed of the training objectives in the programmed materials.

FIGURE C-1. STUDENT ATTITUDE QUESTIONNAIRE

A - Strongly Disagree
B - Disagree
C - Neutral
D - Agree
E - Strongly Agree

15. The learning materials were well organized and clearly presented.

16. I know how to perform the hands-on procedures, but I don't really understand what I'm doing.

17. I guessed at most of the answers to questions in the programmed texts.

18. Programmed instruction made learning too mechanical.

19. The programmed instruction was boring.

20. I found myself trying to get through the programmed texts rather than trying to learn.

21. The method by which I was told whether I had given a right or wrong answer in the programmed texts became monotonous.

22. I would like to have more audio-visual lessons.

23. The audio-visuals in this course explained things well.

24. The instructors helped me and encouraged me to do well.

25. The instructor was available whenever I needed him.

26. I felt the instructors were positive toward self-paced instruction.

27. The instructors took the time to satisfactorily answer my questions.

28. I felt I was not given enough personal attention.

29. I could have gone faster if there had been more equipment to use.

30. I felt no one really cared whether I worked or not.

31. I felt frustrated by the way the course was run.

32. When I finished a lesson, I often had to wait a long time before I could start the next lesson.

33. There were occasions when I was at my carrel with nothing to do.

FIGURE C-1 (Continued)

A - Strongly Disagree
B - Disagree
C - Neutral
D - Agree
E - Strongly Agree

34. I felt frustrated by the number of tests I had to take.

35. I felt the self-tests were a waste of my time.

36. I could pass the block tests, but I really didn't understand the material.

37. I found it hard to concentrate because the room was too noisy.

38. There are too many distractions with this method of self-paced instruction.

39. I wish I could have spent more time away from my carrel.

40. I liked the idea of having my own study carrel.

We would like you to tell us how you felt about the materials in your own words. On the back of your answer sheet, state how you felt about the specific materials and how you felt about the way the material was presented.

FIGURE C-1 (Concluded)

TABLE C-1

PERCENTAGES OF POSITIVE (+), NEUTRAL (0) AND NEGATIVE (-) RESPONSES TO THE STUDENT ATTITUDE ITEMS

| | ITEM | IM COURSE | | | MF COURSE | | | PME COURSE | | | WM COURSE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | - | 0 | + | - | 0 | + | - | 0 | + | - | 0 | + |
| 1. | Could work at own pace | 5% | 6% | 89% | 6% | 9% | 85% | 7% | 8% | 85% | 8% | 7% | 85% |
| 2. | Felt satisfied with what was learned | 10 | 11 | 79 | 3 | 14 | 83 | 13 | 21 | 66 | 10 | 22 | 68 |
| 3. | Could talk with instructor | 19 | 16 | 65 | 22 | 15 | 63 | 14 | 14 | 72 | 15 | 30 | 55 |
| 4. | Feel favorable toward materials | 4 | 18 | 78 | 5 | 20 | 75 | 11 | 26 | 63 | 9 | 27 | 64 |
| 5. | Anxious to get next AF assignment | 4 | 11 | 85 | 4 | 12 | 84 | 6 | 18 | 76 | 1 | 14 | 85 |
| 6. | AF training will help get civilian job | 5 | 11 | 84 | 5 | 16 | 79 | 5 | 12 | 83 | 25 | 35 | 40 |
| 7. | Did feel, should hurry to finish course | 12 | 23 | 65 | 16 | 26 | 58 | 13 | 37 | 50 | 17 | 35 | 48 |
| 8. | Did not fill out too many forms | 18 | 42 | 40 | 18 | 44 | 38 | 28 | 40 | 32 | 32 | 45 | 23 |
| 9. | Did not need more work in groups | 32 | 32 | 34 | 26 | 31 | 43 | 24 | 36 | 40 | 31 | 45 | 24 |
| 10. | Self-paced was good use of time | 8 | 9 | 83 | 5 | 11 | 84 | 7 | 18 | 75 | 6 | 14 | 80 |
| 11. | Did see reason to hurry in course | 18 | 25 | 58 | 24 | 25 | 51 | 27 | 35 | 38 | 23 | 40 | 37 |
| 12. | Self-paced is better way than lecture | 17 | 26 | 57 | 12 | 22 | 66 | 21 | 32 | 47 | 11 | 22 | 67 |
| 13. | Prefer other courses be self-paced | 19 | 27 | 54 | 10 | 27 | 63 | 20 | 34 | 46 | 10 | 23 | 67 |
| 14. | Liked objectives stated in materials | 3 | 25 | 72 | 3 | 19 | 78 | 3 | 24 | 73 | 3 | 20 | 77 |
| 15. | Learning materials were well organized | 10 | 19 | 71 | 6 | 16 | 78 | 30 | 31 | 39 | 14 | 37 | 49 |
| 16. | Can follow and understand procedures | 15 | 26 | 59 | 10 | 29 | 61 | 17 | 20 | 63 | 14 | 34 | 52 |
| 17. | Did not guess at most test questions | 4 | 7 | 89 | 7 | 7 | 86 | 5 | 7 | 88 | 6 | 1 | 83 |
| 18. | Learning was not made too mechanical | 13 | 26 | 61 | | 28 | 60 | 15 | 29 | 56 | 10 | 33 | 57 |
| 19. | Instruction was not boring | 16 | 31 | 53 | 1 | 31 | 56 | 19 | 35 | 46 | 15 | 37 | 48 |
| 20. | Tried to learn, not just to get through | 24 | 26 | 50 | 15 | 22 | 63 | 24 | 21 | 55 | 21 | 31 | 48 |
| 21. | Feedback did not become monotonous | 14 | 24 | 62 | 10 | 27 | 63 | 13 | 28 | 59 | 14 | 27 | 59 |
| 22. | Did not need more audiovisual lessons | 20 | 31 | 49 | 21 | 32 | 47 | 33 | 34 | 33 | 28 | 29 | 43 |
| 23. | Audiovisuals explained things well | 22 | 33 | 45 | 19 | 31 | 50 | 16 | 31 | 53 | 24 | 32 | 44 |
| 24. | Instructors gave help and encouragement | 3 | 8 | 89 | 2 | 13 | 85 | 5 | 19 | 76 | 12 | 31 | 57 |
| 25. | Instructor was available when needed | 6 | 12 | 82 | 4 | 10 | 86 | 14 | 19 | 67 | 8 | 22 | 70 |
| 26. | Instructors were positive to self-pacing | 5 | 18 | 77 | 3 | 15 | 82 | 8 | 26 | 66 | 11 | 26 | 63 |
| 27. | Instructors answered questions well | 7 | 6 | 87 | 5 | 11 | 84 | 5 | 15 | 80 | 11 | 24 | 65 |
| 28. | Did get enough personal attention | 5 | 14 | 81 | 8 | 12 | 80 | 6 | 21 | 73 | 8 | 31 | 61 |
| 29. | Progress wasn't limited by equipment | 8 | 28 | 64 | 10 | 30 | 60 | 16 | 27 | 57 | 34 | 34 | 32 |
| 30. | Did feel I really should work | 5 | 9 | 86 | 7 | 9 | 84 | 5 | 20 | 75 | 8 | 25 | 67 |
| 31. | Was not frustrated by way course was run | 9 | 13 | 78 | 7 | 17 | 76 | 15 | 25 | 60 | 18 | 34 | 48 |
| 32. | Did not have to wait between lessons | 8 | 12 | 80 | 6 | 10 | 84 | 7 | 9 | 84 | 34 | 23 | 43 |
| 33. | When at carrel, did have something to do | 14 | 11 | 75 | 8 | 9 | 83 | 8 | 10 | 82 | 34 | 14 | 52 |
| 34. | Was not frustrated by number of tests | 11 | 24 | 65 | 10 | 24 | 66 | 11 | 23 | 66 | 17 | 31 | 52 |
| 35. | Did not feel self-tests were waste of time | 9 | 11 | 80 | 6 | 10 | 84 | 5 | 14 | 81 | 6 | 17 | 77 |
| 36. | Could pass tests and did understand material | 10 | 17 | 73 | 6 | 14 | 80 | 8 | 21 | 71 | 11 | 27 | 62 |
| 37. | Was not too noisy or hard to concentrate | 10 | 15 | 75 | 8 | 17 | 75 | 20 | 23 | 57 | 20 | 27 | 53 |
| 38. | Were not too many distractions | 8 | 18 | 74 | 4 | 13 | 83 | 17 | 22 | 61 | 11 | 27 | 62 |
| 39. | Didn't want more time away from carrel | 19 | 29 | 52 | 20 | 28 | 52 | 30 | 46 | 24 | 40 | 38 | 22 |
| 40. | Liked having own study carrel | 6 | 14 | 80 | 6 | 17 | 77 | 3 | 25 | 72 | 5 | 20 | 75 |
| | AVERAGE PERCENTAGES | 11.4 | 19.1 | 69.4 | 9.8 | 19.4 | 70.8 | 13.9 | 23.8 | 62.3 | 15.9 | 27.6 | 56.5 |

AD-A081 854 MCDONNELL DOUGLAS ASTRONAUTICS CO ST LOUIS MO F/G 5/9
INTEGRATED SYSTEM TEST OF THE ADVANCED INSTRUCTIONAL SYSTEM (AI--ETC(U)
DEC 79 L M LINTZ, R PENNELL, J Y YASUTAKE F33615-73-C-4004
UNCLASSIFIED AFHRL-TR-79-40 NL

END
DATE FILMED
4-80
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TABLE C-2

AVERAGE ATTITUDE SCORES FROM THE AIS COURSES

| | PHASE I: BASELINE CMI | | PHASE II: CMI PLUS SPM | |
|---|---|---|---|---|
| IM COURSE | IIA | MAIN TRACK | IIA | MAIN TRACK |
| END OF BLOCK I | 3.97 (N=156) | 3.90 (N=122) | 3.92 (N=123) | 3.98 (N=133) |
| END OF COURSE | 3.95 (75) | 3.79 (86) | 3.80 (59) | 3.79 (61) |
| HF COURSE | IIA | RANDOM | IIA | RANDOM |
| END OF BLOCK I | 3.84 (46) | 3.93 (95) | 3.89 (47) | 3.85 (52) |
| END OF COURSE | 3.80 (22) | 3.90 (30) | 3.92 (43) | 3.79 (22) |
| PME COURSE | | RANDOM | | LEARNER CHOICE |
| END OF BLOCK VII | | 3.69 (58) | | 3.70 (34) |
| END OF COURSE | | 3.62 (101) | | --* |
| WM COURSE | | RANDOM | | HEURISTICS |
| END OF BLOCK V | | 3.73 (597) | | 3.63 (696) |
| END OF COURSE | | 3.71 (176) | | 3.53 (167) |

* No data. Blocks X, XI and XII of PME were not under SPM during the period covered in this Interim Report.

# APPENDIX D

# GLOSSARY OF TERMS

## GLOSSARY OF TERMS

ACCEPTANCE TEST - Designed to confirm that each of the four prototype AIS courses fulfill requirements of the Statement of Work. Acceptance testing was incrementally conducted and includes visual inspection, data analysis, tests under controlled conditions and demonstrations. Covered are hardware, software, instructional materials, media and documentation, wherever appropriate.

ADAPTIVE MODEL - Consists of a set of computer programs that generate Individual Instructional Assignments, predict and assign individual block and course completion time targets (Student Progress Management), allocates training resources and is the vehicle for accomplishing continual test and courseware evaluation and refinement.

ADVANCED INSTRUCTIONAL SYSTEM (AIS) - A prototype, comprehensive computer-managed and computer-assisted instructional system to provide the following automated capabilities in support of large scale training: Individual Instructional Assignments, Student Progress Management, resource allocation and scheduling, information storage and report generation and evaluation and research.

ALTERNATIVE MODULES - Modules utilizing different instructional approaches from previously existing modules to meet the specific needs of particular types of students and/or certain course requirements. (See Instructional Module).

AUDIO-VISUAL (A/V) - A method of displaying information in which both the Audio segment and Visual segment are electro-mechanically and optically reproduced for the information of the student, e.g., photographic slides used in conjunction with an audio tape player.

AUDIO-VISUAL MODULES - A segment of instruction characterized by format and not by content. Generally, the format is such that the visuals are optically presented to the student and the audio is electro-mechanically presented.

BLOCK - A course component comprised of lessons and modules that cover a specific subject/content area and normally ends with a comprehensive test.

BASELINE CMI - A list of CMI support functions operative in the prototype AIS courses at the start of the IST.

BLOCK COMPLETION/ELAPSED TIMES - The period of time from inception of a block's first lesson or lesson group through completion of the block test.

## GLOSSARY OF TERMS (Continued)

CENTRAL PROCESSING UNIT (CPU) - The element of a systems' computer hardware that performs necessary arithmetic, manipulative and logic operations.

CHI-SQUARE ($\chi^2$) ANALYSES - The chi-square analysis (test) is used to determine the statistical significance of differences in the number of observations between two or more groups.

COMPLEMENTARY TECHNICAL TRAINING (CTT) - Course related training performed in addition to normal classroom training without the aid of an instructor, i.e., homework.

COMPULSORY REMEDIAL TRAINING (CRT) - Directed remedial training when a student's academic performance falls below established minimal standards.

COMPUTER-ASSISTED INSTRUCTION (CAI) - An instructional mode which provides instruction via an interactive computer terminal. Tutorial instruction and/or simulation takes place at the terminal and other instructional media may be integrated with the terminal display. Utilization ratio is one student per interactive terminal.

COMPUTER-BASED - CAI and/or CMI support of instructional programs.

COMPUTER HARDWARE - The hardware components that comprise the computer system and includes the central processor, various types of memory units, printout unit and control, display and distribution units.

COMPUTER-MANAGED INSTRUCTION (CMI) - Use of the computer to manage students through the instructional process. The computer's role is that of a diagnostician and manager of instructional events. Through the Adaptive Model, it generates Individual Instructional Assignments (IIAs), predicts and assigns individual block and course completion times, allocates training resources and evaluates tests and courseware. The utilization ratio is 100 students per management terminal.

COMPUTER SOFTWARE - A logical grouping of programmed computer codes that gives commands to a computer to perform a particular function. A unique AIS software component is the Computer Assisted/Managed Instructional Language (CAMIL) that facilitates both CAI and CMI.

CONFIGURATION CONTROL - Appropriate management control over the large number of course related factors (e.g., course content and taxonomy, tests and test keys and resource inventories) that affect performance of the AIS to assure avoidance of unnecessary, untimely and uncoordinated changes.

## GLOSSARY OF TERMS (Continued)

CONVENTIONAL TRAINING - Classroom and/or laboratory training conducted in a previously established and accepted manner, i.e., usually a classroom lecturer and/or laboratory instructor-student group relationship in a lock-step mode of progress.

COURSE - A block or a series of blocks of instruction designed to satisfy Specialty Training Standards for a particular Air Force Specialty Code and skill level. Formal, resident training conducted at an Air Training Command installation.

COURSE COMPLETION PREDICTIONS - A computer-generated estimate of a student's time required to complete the course based upon Preassessment Testing. Predictions may be made for completion of modules, lessons, or blocks as well as for the entire course.

COURSE COMPLETION TARGET - A course completion prediction adjusted for course policy regarding the desired minimum, maximum and average course completion times.

COURSE COMPLETION TIMES - Measured classroom time from course entry to graduation.

COURSE DATA BASE - A collection of computerized files containing the parameters and flags which control the operation of the Adaptive Model for a specific course.

COURSE EVALUATION SUMMARY (CES) - A computer generated report of student performance data (e.g., average completion times and scores and failure rates) available for one, selected combinations, or all lessons and/or blocks of a specific course. The CES summarizes student performance at the module, lesson and block level.

COURSEWARE - Generic term for all AIS instructional material.

COVARIANCE - A statistical technique to control for group differences in ability or other factors so that these differences tend not to affect time and score comparisons.

CRITERION VARIABLES - Measures of student performance, times and score, on lesson and block tests.

DAILY ROSTER - A computer generated listing of students assigned to a specific learning center, their assigned carrel numbers, current block of instruction, and rate of progress relative to their target course completion rate.

## GLOSSARY OF TERMS (Continued)

DECISION MODEL - A type of mathematical or logical model used in the selection of alternative modules for AIS lessons. (See Heuristic and Regression Models.)

EQUIVALENCE OF GROUPS - Analysis of groups of students included in the IST to assure that they do not vary significantly in ability or other psychological variables (preassessment) and, as a result, do not bias the results of the time savings analyses.

EXTENDED CORE STORAGE (ECS) - The ECS is a component of the computer hardware system. It is a random access, word-organized, mass storage device.

FIRST ATTEMPT BLOCK FAILURES - A computer produced list of the number of students who fail to meet criterion on their first attempt to pass an end-of-block test.

HEURISTIC MODELS - Logical "If...then" statements used to assign students to alternative modules. These logical statements can be based solely on expert judgement, on previously collected and analyzed data, or on a combination of both.

INDIVIDUALIZATION - See Individualized Instructional Assignment.

INDIVIDUALIZED INSTRUCTIONAL ASSIGNMENT (IIA) - The AIS/CMI capability to assign individual students to alternative modules of instruction for a lesson in order to achieve optimal performance from each student.

INSTRUCTIONAL MATERIALS - Printed, audio, or visual information used in instruction. Includes programmed texts, picture books, workbooks, audio visuals, checklists, technical orders and tests.

INSTRUCTIONAL MODULE - A specific package of instructional materials and related training resources for presentation of a specific AIS lesson. A lesson may have more than one instructional module. All modules for a lesson teach the same objectives but differ in the method of presentation and/or strategies used.

INTERACTIVE (A) TERMINAL - Consists of a plasma display and keyboard and is used by instructors and course authors to interact with the AIS central computer and data files and by students for on-line, adaptive testing and CAI.

## GLOSSARY OF TERMS (Continued)

KEYPRESSES - A data word request for computer service initiated at either an Interactive or Management Terminal. Depending on the service requested, a keypress can generate from one hundred to a thousand instructions for performance by the Central Processor Unit (CPU).

LEARNER CHOICE - The option for individual students to make their own selection of available alternative modules for lessons so designated.

LEARNING CENTERS - A learning environment to which students are assigned for attendance-taking purposes and in which most coursework is conducted. Consists of carrels, media and job related equipment and/or simulators designed to support individualized instruction.

LESSON - A component of a block of instruction. Contains instructional information to enable achievement of a learning objective or series of objectives. A lesson is learned through the use of one or more specific instructional modules.

LOCK-STEP - Traditional presentation of instruction, to an integrated group/class in unison and in accordance with a fixed plan and schedule.

MAIN TRACK - The first AIS module implemented for a course and designed to best satisfy the training requirements of a majority of the students.

MANAGEMENT "B" TERMINAL - Consists of a forms reader, printer and mini-computer and is used to read and score test forms, transmit data to and receive information from the AIS central computer, and print student prescriptions and management reports.

MANUAL SELF-PACING - Manual management and tracking of self-pacing within a course without CMI support.

MEDIA - Channels of communications and/or substances for use in transmission of force or effect, i.e., effective means of transmitting course material to students.

MEDIA DEVICE - Generally, a type of electro-mechanical/optical device to display either audio, visual, or both in an effective manner to an information receiver, i.e., a student.

MEDIA OVERLAP - A module which differs from another module only in the mode of presentation. For example, narrated filmstrips and illustrated texts may have identical words and pictures, but because the first is audio-visual and the other is printed, they represent media overlap.

## GLOSSARY OF TERMS (Continued)

MEDIA SYSTEM - The gamut of medium equipment, processes, people and materials necessary for effective presentation of information and learner activity. Usually includes media courseware, hardware, planning, production, recording and/or transmitting and program reception.

MODULE - The smallest testable unit of instruction within a block of instruction. A set of instructional materials which applies a specific instructional approach for teaching a lesson. (See Instructional Module).

MULTI-TRACK - A concept used to describe individualization strategies used in alternative modules for a lesson. For example, alternative modules for a lesson may be produced to accommodate student needs by using mediums and different levels of redundancy or difficulty. Thus, the presentation strategies will differ for alternative modules in the multi-tracking category; presentation media may or may not differ.

PREASSESSMENT DATA - The results of a test battery given to students before they begin a course. The battery is designed to measure student abilities, attitudes, interests and backgrounds. Preassessment data, in conjunction with Within-Course Testing is used for Individualized Instructional Assignment and Student Progress Management.

PRESCRIPTION - A computer generated student status report indicating the student's performance on his/her last assignment, his/her next assignment and related training resources required, if any.

RANDOM ASSIGNMENT - The option to specify the percentage of students who should be assigned randomly to the alternative module for a lesson. Provides experimental control groups for AIS related research and/or for development of regression equations.

REGRESSION EQUATION - Statistical methodology employed in calculating regression modules. The mathematical equation which provides the best prediction (least squares fit) of expected student performance. Regression equations are based on the actual performance of prior groups of students.

REGRESSION MODELS - A method of selecting alternative modules utilizing regression equations which predict student performance on each alternative. The prediction is based on preassessment data, prior within-course performance, or a combination of both.

RESOURCE ALLOCATION - A CMI function of the Adaptive Model for managing all training resources declared in the Course Data Base as computer-managed. The AIS capability to balance student flow through a module, lesson, block or course to avoid queueing as a result of resource unavailability and to maximize use of critical resources.

SELF-PACED CMI COURSE - A self-paced course supported by, as a minimum, baseline CMI.

SELF-PACING - A generic description of programs where learning and progress occur at each student's self-established pace. Generally, students whose rate of progress exceeds predetermined limits are counseled.

SOFTWARE - See Computer Software

SPECIALTY TRAINING STANDARD (STS) - Air Force established standards that specify knowledge and skill requirements for training in Air Force Specialty Codes and are the primary control documents for Type III (formal/resident) courses.

STATE-OF-THE-ART - Current level, state, or condition of technology in disciplines related to computer-based education and training.

STATISTICAL SIGNIFICANCE - The probability that the observed difference between groups could occur by chance alone.

STRATEGIES - Specific instructional techniques applied within a module, lesson, block or other sequence of instruction and designed to meet individual needs and characteristics of various types of students considering the particular learning objective.

STUDENT DATA PROFILE (SDP) - A computerized file that maintains comprehensive records for each student enrolled in an AIS course. Each student record contains bibliographic, preassessment and within-course performance data.

STUDENT PROGRESS MANAGEMENT (SPM) - The AIS capability to predict and assign individual block and course completion time targets based on each student's individual aptitudes, ability, and performance and to provide students and instructors with daily feedback on each student's progress toward the target completion times.

TARGETED COURSE COMPLETION RATE - A computer generated rate of progress through a course for each student which he/she must maintain to meet the course completion target.

GLOSSARY OF TERMS (Concluded)

**TWO-WAY ANALYSES OF VARIANCE** - Statistical technique for evaluating the significance of differences between groups.

WITHIN COURSE DATA - Data describing student performance (lesson and block times and scores) within a course as compared to preassessment and/or bibliographic data.